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San Francisco WASTEWATER TREATMENT PILOT PLANT STUDY

VOLUME II
Appendixes A-I

SAN FRANCISCO WASTEWATER TREATMENT PILOT PLANT STUDY

FOR
CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS

VOLUME II, APPENDIXES A–I

By

CH2M HILL, INC.
360 Pine Street
San Francisco, California 94104

May 1974

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SOUTHEAST STP INFLUENT ANALYSIS - HEAVY METALS

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ALUMINUM	UG/L	5,740	7,930	8,310	3,620	4,180	5,210	1,780	4,600	26,280	4,570	2,900	14,740	2,920	2,380
ANTIMONY	UG/L	100	130	130	17	40	70	270	250	120	170	140	200	170	130
ARSENIC	UG/L	3.6	4.4	4.2	4.4	4.4	7.4	4.3	3.2	2.2	6.5	4.5	5.4	3.6	3.9
BARIUM	UG/L	500	100	80	30	20	50	80	80	100	70	90	80	100	60
BERYLLIUM	UG/L	3.6	3.7	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0
BISMUTH	UG/L	100	100	150	230	50	100	120	100	120	20	80	100	200	200
BORON	UG/L	570	790	620	720	630	200	890	1,470	340	910	120	1,110	580	600
CADMIUM	UG/L	3.0	2.0	5.0	4.0	6.0	4.0	3.7	2.5	3.4	2.6	4.0	2.0	2.0	1.0
CALCIUM	UG/L	58	54	43	50	43	43	63	60	43	50	38	50	46	46
CHROMIUM	UG/L	1,600	2,400	6,600	3,200	2,300	2,100	2,700	5,000	47	1,600	2,700	5,000	350	320
CR-6	UG/L	5	5	5	5	5	5	5	5	5	5	5	5	5	5
COBALT	UG/L	26.0	21.0	1.0	1.0	10.0	5.0	0.1	0.1	5.0	5.0	1.0	1.0	5.0	5.0
COPPER	UG/L	230	230	240	220	140	120	200	240	120	200	200	240	290	200
CYANIDE	MG/L	0.080	0.060	0.008	0.060	0.035	0.060	0.005	0.040	0.055	0.210	0.005	0.015	0.225	0.150
FE -2	UG/L	120	150	400	200	100	100	280	200	3,000	500	15,000	2,000	200	200
GOLD	UG/L	14.0	7.0	1.0	1.0	5.0	5.0	0.1	0.1	5.0	5.0	1.0	1.0	7.0	6.0
IRON	UG/L	3,830	4,950	6,230	2,170	1,040	1,390	4,010	7,360	8,000	4,570	16,080	8,290	1,170	1,590
LEAD	UG/L	200	190	200	130	98	95	130	130	86	760	130	130	71	50
LITHIUM	UG/L	10	10	15	15	10	14	23	20	12	15	15	18	17	15
MAGNESIUM	UG/L	153,10	138,70	62,34	126,62	67,92	104,30	145,00	128,80	57,14	109,77	40,63	119,78	140,00	139,10
MANGANESE	UG/L	160	160	180	220	150	160	160	190	200	180	160	190	180	180
MERCURY	UG/L	0.24	0.50	1.24	1.00	0.18	0.24	10.00	0.36	0.24	0.34	0.88	0.80	1.06	0.72
MOLYBDENUM	UG/L	20	20	10	18	10	17	220	18	11	18	12	18	20	20
NICKEL	UG/L	49	56	210	180	210	350	22	37	110	37	350	150	20	100
PHOSPORUS	UG/L	9,600	15,000	9,700	6,500	9,500	7,500	7,300	5,600	8,000	6,600	10,700	6,900	8,000	7,100
POTASSIUM	MG/L	62.0	69.0	32.0	41.0	17.0	35.0	63.0	38.0	51.0	64.0	37.0	54.0	49.0	51.0
SELENIUM	UG/L	10	10	8	4	10	10	23	41	10	10	24	14	10	10
SILICON	UG/L	28,710	39,630	17,660	6,330	7,310	9,560	7,810	11,040	30,860	18,300	5,220	4,610	5,830	4,970
SILVER	UG/L	37	25	31	28	16	14	33	36	25	37	33	36	48	33
SODIUM	MG/L	690	720	370	630	640	820	970	810	430	680	460	770	730	790
STRONTIUM	UG/L	570	790	310	360	310	520	450	550	340	370	460	550	390	400
THALLIUM	UG/L	200	200	100	180	100	170	220	180	110	180	120	180	200	200
TIN	UG/L	38	79	94	18	100	52	22	37	91	37	23	18	20	20
TITANIUM	UG/L	130	240	260	152	112	112	200	200	132	104	580	770	480	280
TUNGSTEN	UG/L	400	400	210	360	210	350	450	370	220	370	230	40	390	400
URANIUM	UG/L	9	10	2	1	3	6	6	6	1	4	4	2	3	7
VANADIUM	UG/L	50	50	10	10	10	10	10	10	10	10	10	10	10	10
ZINC	UG/L	1,550	650	940	430	430	560	780	920	3,500	1,200	48,000	4,000	240	270
ZIRCONIUM	UG/L	150	330	223	173	209	270	389	326	367	289	159	293	181	186

SOUTHEAST STP INFLUENT ANALYSIS - HEAVY METALS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ALUMINUM	UG/L	26,280	1,780	6,150
ANTIMONY	UG/L	270	17	138
ARSENIC	UG/L	7.4	2.2	5.0
BARIUM	UG/L	500	20	67
BERYLLIUM	UG/L	3.7	1.0	1.7
BISMUTH	UG/L	230	20	121
BORON	UG/L	1,470	120	829
CADMIUM	UG/L	6.0	1.0	2.6
CALCIUM	UG/L	63	38	50
CHROMIUM	UG/L	6,600	47	2,803
CR-6	UG/L	5	5	5
COBALT	UG/L	26.0	0.1	5.4
COPPER	UG/L	290	120	207
CYANIDE	MG/L	0.225	0.005	0.085
FE -2	UG/L	15,000	100	479
GOLD	UG/L	14.0	0.1	5.6
IRON	UG/L	16,080	1,040	4,331
LEAD	UG/L	760	50	212
LITHIUM	UG/L	23	10	15
MAGNESIUM	UG/L	153,10	40.63	123.87
MANGANESE	UG/L	220	150	183
MERCURY	UG/L	10.00	0.16	0.57
MOLYBDENUM	UG/L	220	10	18
NICKEL	UG/L	350	20	130
PHOSPORUS	UG/L	15,000	5,600	7,886
POTASSIUM	MG/L	69.0	17.0	50.3
SELENIUM	UG/L	41	4	14
SILICON	UG/L	39,630	4,610	13,491
SILVER	UG/L	48	14	30
SODIUM	MG/L	970	370	746
STRONTIUM	UG/L	790	310	506
THALLIUM	UG/L	220	100	184
TIN	UG/L	100	16	37
TITANIUM	UG/L	770	104	265
TUNGSTEN	UG/L	450	40	327
URANIUM	UG/L	10	1	5
VANADIUM	UG/L	50	10	16
ZINC	UG/L	48,000	240	1,147
ZIRCONIUM	UG/L	389	150	267

SOUTHEAST STP INFLUENT ANALYSIS - PHYSICAL - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
COLOR	UNITS	210	168	145	75	195	145	145	125	180	125	165	125	90	80
CONDUCT.	U-MHO	4,800	5,000	2,160	4,280	3,250	4,610	5,220	4,280	2,290	4,800	2,960	4,800	5,220	4,800
FLOATABLES	MG/L	2.70	3.60	5.50	7.00	4.51	79.60	18.00	33.00	5.90	7.60	3.80	4.40	5.10	6.20
ODOR-RM T	TH-NO.	1023.0	545.0	5000.0	4656.0	9850.0	1700.0	5745.0	5347.0	7580.0	2550.0	1546.0	2464.5	532.0	9935.0
SETTLEABLE	MG/L	7.0	2.5	10.0	5.0	8.0	6.0	6.0	5.0	5.5	6.0	13.0	6.0	11.0	2.0
TOT DIS SOL	MG/L	2,240	2,430	1,210	1,770	1,540	2,160	2,940	2,160	1,114	1,970	1,470	2,180	2,398	1,972
TOT SOLIDS	MG/L	2,540	2,700	1,620	2,050	1,860	2,460	3,400	2,530	1,490	2,330	1,833	2,490	2,634	2,122
TOT SUS MAT	MG/L	300	262	402	272	328	301	462	373	376	354	365	315	235	150
TOT VOL SOL	MG/L	649	644	489	556	511	490	826	677	563	605	644	558	567	441
TURBIDITY	JTU	210	228	260	210	220	230	220	210	215	200	260	200	180	100
VOL SUS MAT	MG/L	253	222	326	230	280	254	380	310	297	270	266	222	203	136
TEMPERATURE	DEG-C	18.6	20.0	19.5	20.5	18.5	19.5	19.0	20.0	29.5	20.0	18.0	19.5	19.0	20.5

4/16/73 - 4/28/73

SOUTHEAST STP INFLUENT ANALYSIS - PHYSICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
COLOR	UNITS	210	75	120
CONDUCT.	U-MHO	5,220	2,160	4,653
FLOATABLES	MG/L	79.60	2.70	20.20
ODOR-RM T	TH-NO.	112,550.0	532.0	23,885.4
SETTLEABLE	MG/L	13.0	2.0	4.6
TOT DIS SOL	MG/L	2,940	1,114	2,092
TOT SOLIDS	MG/L	3,400	1,490	2,383
TOT SUS MAT	MG/L	462	150	290
TOT VOL SOL	MG/L	826	441	567
TURBIDITY	JTU	260	100	197
VOL SUS MAT	MG/L	380	136	235
TEMPERATURE	DEG-C	29.5	18.0	20.0

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ACID(CACO3)	MG/L	42.9	45.2	19.0	33.0	105.0	48.0	28.0	24.0	8.2	21.0	165.0	22.0	15.0	16.0
ALKA(CACO3)	MG/L	186	179	222	164	120	172	172	184	266	177	72	177	196	172
BOD(5 DAY)	MG/L	329	192	299	222	278	412	299	254	380	262	214	176	133	126
BOD(ULTIM)	MG/L	690	550	390	320	1,300	690	580	420	1,200	800	480	450	420	420
BROMIDE	MG/L	2.90	13.00	0.20	0.15	0.10	0.10	6.70	4.60	2.00	3.40	0.10	0.10	2.00	1.90
CO2	MG/L	37.7	40.0	17.0	29.0	93.0	51.0	25.0	21.0	7.2	19.0	145.0	19.0	1.3	14.0
CHLORIDE	MG/L	1,010	1,000	344	979	430	1,020	1,250	946	326	914	491	994	1,040	1,040
COD	MG/L	1,170	1,140	719	651	1,550	675	876	1,310	856	471	593	488	558	736
DIS OXY	MG/L	0.75	2.00	0.00	2.10	2.90	2.90	0.30	2.40	3.10	4.30	0.10	2.10	0.30	2.50
FLUORIDE	MG/L	1.55	0.98	1.05	0.84	1.00	0.94	1.08	1.00	1.05	0.86	1.03	0.60	0.84	0.70
IODIDE	MG/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.010	0.018	0.001	0.001	0.001	0.001
OIL-GR(TOT)	MG/L	91.8	116.9	89.0	61.0	71.8	92.9	37.0	58.0	51.0	45.0	71.0	61.0	45.0	58.0
PH	UNIT	7.8000	8.7000	8.2500	9.0000	6.9000	8.9000	7.2500	8.4000	8.4000	8.6000	6.2500	9.9200	7.4000	7.6000
PHENOLS	MG/L	0.180	0.300	0.115	0.054	0.520	0.935	1.975	0.583	0.125	0.190	0.125	0.160	0.120	0.200
SULFATE	MG/L	240	230	156	236	296	220	260	240	196	250	390	300	212	218
SULFIDE	MG/L	1.50	0.80	2.80	0.60	1.80	0.35	0.90	0.80	3.80	1.10	0.58	0.94	0.22	0.32
SULFITE	MG/L	6.4	6.0	13.0	5.3	12.0	2.8	3.0	4.0	9.2	4.0	2.1	2.5	2.0	2.0
SURFACTANTS	MG/L	6.0	6.6	7.5	7.5	7.3	8.6	6.5	6.9	7.4	7.1	7.3	9.3	6.5	6.1
TOT HARD	MG/L	500	460	210	480	300	450	560	460	250	420	260	450	500	490
TOT ORG CAR	MG/L	205	175	285	204	174	353	167	178	263	149	156	110	78	80

4/16/73 - 4/28/73

SOUTHEAST STP INFLUENT ANALYSIS - CHEMICAL AND BIOCHEMICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ACID(CACO3)	MG/L	165.0	8.2	29.9
ALKA(CACO3)	MG/L	266	72	175
BOD(5 DAY)	MG/L	412	126	235
BOD(ULTIM)	MG/L	1,300	320	521
BROMIDE	MG/L	13.00	0.10	3.32
CO2	MG/L	145.0	1.3	27.6
CHLORIDE	MG/L	1,250	326	985
COD	MG/L	1,550	471	782
DIS OXY	MG/L	4.30	0.00	2.61
FLUORIDE	MG/L	1.55	0.60	0.85
IODIDE	MG/L	0.018	0.001	0.003
OIL-GR(TOT)	MG/L	116.9	37.0	70.4
PH	UNIT	9.9200	6.2500	8.7314
PHENOLS	MG/L	1.975	0.054	0.346
SULFATE	MG/L	390	156	242
SULFIDE	MG/L	3.80	0.22	0.70
SULFITE	MG/L	13.0	2.0	3.8
SURFACTANTS	MG/L	9.3	6.0	7.4
TOT HARD	MG/L	560	210	459
TOT ORG CAR	MG/L	353	78	178

SOUTHEAST STP - INFLUENT ANALYSIS - NUTRIENTS - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
AMMONIA-N	MG/L	20.0	14.0	22.0	16.0	16.6	13.0	14.0	11.2	22.0	14.0	40.0	29.0	21.0	12.0
NITRATE-N	MG/L	0.40	1.20	0.02	0.01	0.02	0.13	0.27	0.31	0.09	0.12	0.39	0.52	0.04	0.15
NITRITE-N	MG/L	0.01	0.01	0.01	0.06	0.01	0.19	0.01	0.02	0.01	0.61	0.11	0.15	0.01	0.16
ORGANIC-N	MG/L	34.0	14.0	8.0	24.0	43.4	25.0	16.0	19.0	48.0	27.0	30.0	23.0	18.0	19.0
TOTAL N	MG/L	54	28	30	40	60	38	25	30	70	41	70	52	39	31
ORTHO-P	MG/L	4.5	3.6	6.0	3.7	6.0	5.5	4.8	3.3	5.1	4.0	0.5	0.9	4.9	3.4
TOTAL-P	MG/L	9.6	15.0	9.7	6.5	9.9	7.5	7.3	5.6	9.1	6.6	10.7	6.9	8.0	7.1

4/16/73 - 4/28/73

SOUTHEAST STP - INFLUENT ANALYSIS - NUTRIENTS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
AMMONIA-N	MG/L	40.0	11.2	15.6
NITRATE-N	MG/L	1.20	0.01	0.35
NITRITE-N	MG/L	0.61	0.01	0.17
ORGANIC-N	MG/L	48.0	8.0	21.6
TOTAL N	MG/L	70	25	37
ORTHO-P	MG/L	6.0	0.5	3.2
TOTAL-P	MG/L	15.0	5.6	7.9

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ACID(CACO3)	MG/L	42.9	45.2	19.0	33.0	105.0	48.0	28.0	24.0	8.2	21.0	165.0	22.0	15.0	16.0
ALKA(CACO3)	MG/L	186	179	222	164	120	172	172	184	266	177	72	177	196	172
BOD(5 DAY)	MG/L	329	192	299	222	278	412	299	254	380	262	214	176	133	126
BOD(ULTIM)	MG/L	690	550	390	320	1,300	690	580	420	1,200	800	480	450	420	420
BROMIDE	MG/L	2.90	13.00	0.20	0.15	0.10	0.10	6.70	4.60	2.00	3.40	0.10	0.10	2.00	1.90
CO2	MG/L	37.7	40.0	17.0	29.0	93.0	51.0	25.0	21.0	7.2	19.0	145.0	19.0	1.3	14.0
CHLORIDE	MG/L	1,010	1,000	344	979	430	1,020	1,250	946	326	914	491	994	1,040	1,040
COD	MG/L	1,170	1,140	719	651	1,550	675	876	1,310	856	471	593	488	558	736
DIS OXY	MG/L	0.75	2.00	0.00	2.10	2.90	2.90	0.30	2.40	3.10	4.30	0.10	2.10	0.30	2.50
FLUORIDE	MG/L	1.55	0.98	1.05	0.84	1.00	0.94	1.08	1.00	1.05	0.86	1.03	0.60	0.84	0.70
IODIDE	MG/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.010	0.018	0.001	0.001	0.001	0.001
OIL-GR(TOT)	MG/L	91.8	116.9	89.0	61.0	71.8	92.9	37.0	58.0	51.0	45.0	71.0	61.0	45.0	58.0
PH	UNIT	7.8000	8.7000	8.2500	9.0000	6.9000	8.9000	7.2500	8.4000	8.4000	8.6000	6.2500	9.9200	7.4000	7.6000
PHENOLS	MG/L	0.180	0.300	0.115	0.054	0.520	0.935	1.975	0.583	0.125	0.190	0.125	0.160	0.120	0.200
SULFATE	MG/L	240	230	156	236	296	220	260	240	196	250	390	300	212	218
SULFIDE	MG/L	1.50	0.80	2.80	0.60	1.80	0.35	0.90	0.80	3.80	1.10	0.58	0.94	0.22	0.32
SULFITE	MG/L	6.4	6.0	13.0	5.3	12.0	2.8	3.0	4.0	9.2	4.0	2.1	2.5	2.0	2.0
SURFACTANTS	MG/L	6.0	6.6	7.5	7.5	7.3	8.6	6.5	6.9	7.4	7.1	7.3	9.3	6.5	6.1
TOT HARD	MG/L	500	460	210	480	300	450	560	460	250	420	260	450	500	490
TOT ORG CAR	MG/L	205	175	285	204	174	353	167	178	263	149	156	110	78	80

4/16/73 - 4/28/73

SOUTHEAST STP INFLUENT ANALYSIS - CHEMICAL AND BIOCHEMICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ACID(CACO3)	MG/L	165.0	8.2	29.9
ALKA(CACO3)	MG/L	266	72	175
BOD(5 DAY)	MG/L	412	126	235
BOD(ULTIM)	MG/L	1,300	320	521
BROMIDE	MG/L	13.00	0.10	3.32
CO2	MG/L	145.0	1.3	27.6
CHLORIDE	MG/L	1,250	326	985
COD	MG/L	1,550	471	782
DIS OXY	MG/L	4.30	0.00	2.61
FLUORIDE	MG/L	1.55	0.60	0.85
IODIDE	MG/L	0.018	0.001	0.003
OIL-GR(TOT)	MG/L	116.9	37.0	70.4
PH	UNIT	9.9200	6.2500	8.7314
PHENOLS	MG/L	1.975	0.054	0.346
SULFATE	MG/L	390	156	242
SULFIDE	MG/L	3.80	0.22	0.70
SULFITE	MG/L	13.0	2.0	3.8
SURFACTANTS	MG/L	9.3	6.0	7.4
TOT HARD	MG/L	560	210	459
TOT ORG CAR	MG/L	353	78	178

SOUTHEAST STP - INFLUENT ANALYSIS - NUTRIENTS - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
AMMONIA-N	MG/L	20.0	14.0	22.0	16.0	16.6	13.0	14.0	11.2	22.0	14.0	40.0	29.0	21.0	12.0
NITRATE-N	MG/L	0.40	1.20	0.02	0.01	0.02	0.13	0.27	0.31	0.09	0.12	0.39	0.52	0.04	0.15
NITRITE-N	MG/L	0.01	0.01	0.01	0.06	0.01	0.19	0.01	0.02	0.01	0.61	0.11	0.15	0.01	0.16
ORGANIC-N	MG/L	34.0	14.0	8.0	24.0	43.4	25.0	16.0	19.0	48.0	27.0	30.0	23.0	18.0	19.0
TOTAL N	MG/L	54	28	30	40	60	38	25	30	70	41	70	52	39	31
ORTHO-P	MG/L	4.5	3.6	6.0	3.7	6.0	3.5	4.8	3.3	5.1	4.0	0.5	0.9	4.9	3.4
TOTAL-P	MG/L	9.6	15.0	9.7	6.5	9.9	7.5	7.3	5.6	9.1	6.6	10.7	6.9	8.0	7.1

4/16/73 - 4/28/73

SOUTHEAST STP - INFLUENT ANALYSIS - NUTRIENTS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
AMMONIA-N	MG/L	40.0	11.2	15.6
NITRATE-N	MG/L	1.20	0.01	0.35
NITRITE-N	MG/L	0.61	0.01	0.17
ORGANIC-N	MG/L	48.0	8.0	21.6
TOTAL N	MG/L	70	25	37
ORTHO-P	MG/L	6.0	0.5	3.2
TOTAL-P	MG/L	15.0	5.6	7.9

SOUTHEAST STP - INFLUENT ANALYSIS - BIOASSAYS - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
TLM-24 HR	%	67	87	35		37	90			61	86	86		61	88
TLM-48 HR	%	61	87	35		37	90			61	86	86		61	85
TLM-96 HR	%	59	87	35		37	90			61	86	81		51	81
SURVIVAL-24	%	0	0	0	100	0	20	90	80	0	0	0	100	0	10
SURVIVAL-48	%	0	0	0	100	0	20	90	70	0	0	0	100	0	0
SURVIVAL-96	%	0	0	0	80	0	20	60	70	0	0	0	100	0	0
TOXICITY	UNITS	1.69	1.15	2.86	0.77	2.70	1.11	0.94	0.87	1.64	1.16	1.23	0.00	1.64	1.23

4/16/73 - 4/28/73

SOUTHEAST STP - INFLUENT ANALYSIS - BIOASSAYS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
TLM-24 HR	%	90	35	88
TLM-48 HR	%	90	35	87
TLM-96 HR	%	90	35	86
SURVIVAL-24	%	100	0	44
SURVIVAL-48	%	100	0	41
SURVIVAL-96	%	100	0	39
TOXICITY	UNITS	2.86	0.00	0.90

SOUTHEAST STP - INFLUENT ANALYSIS - RADIOACTIVE SUBSTANCES - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
GROSS ALPHA	PC/L	19	16	10	18	10	10	70	21	12	17	25	70	21	19
GROSS BETA	PC/L	76	49	38	176	33	40	74	68	37	77	56	95	87	92
RADIUM 226	PC/L	0.09	0.09	0.20	0.10	0.20	0.04	0.13	0.14	0.02	0.05	0.09	0.20	0.16	0.20
STRONT. 90	PC/L	0.5	0.5	0.5	0.5	0.5	1.0	0.6	0.5	0.5	1.0	0.5	0.5	0.6	0.5

4/16/73 - 4/28/73

SOUTHEAST STP - INFLUENT ANALYSIS - RADIOACTIVE SUBSTANCES

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
GROSS ALPHA	PC/L	70	10	24
GROSS BETA	PC/L	176	33	85
RADIUM 226	PC/L	0.20	0.02	0.12
STRONT. 90	PC/L	1.0	0.5	0.6

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
LINDANE	UG/L	0.005	0.003	0.306	0.001	0.053	0.007	0.001	0.006	0.123	0.078	0.001	0.001	0.038	0.056
HPT-CL-EPOX	UG/L	0.001	0.001	0.001	0.007	0.001	0.001	0.002	0.001	0.001	0.001	0.003	0.001	0.001	0.001
DDE	UG/L	0.001	0.002	0.017	0.019	0.001	0.020	0.014	0.009	0.045	0.029	0.002	0.004	0.001	0.001
DDD	UG/L	0.001	0.003	0.001	0.001	0.003	0.037	0.001	0.001	0.001	0.001	0.005	0.007	0.001	0.001
DDT	UG/L	0.007	0.033	0.001	0.001	0.010	0.055	0.074	0.060	0.001	0.001	0.023	0.033	0.050	0.113
DIELDRIN	UG/L	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.025	0.001	0.001	0.001	0.001
TOT CL H.C.	UG/L	0.480	0.750	0.708	0.632	4.160	1.884	2.079	0.382	9.211	1.265	1.432	1.960	0.975	1.212
ALDRIN	UG/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CHLORDANE	UG/L	0.001	0.035	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.006	0.001	0.001
ENDRIN	UG/L	0.001	0.006	0.023	0.011	0.001	0.001	0.011	0.006	1.000	0.001	0.001	0.001	0.001	0.001
HEPTACHLOR	UG/L	0.020	0.001	0.001	0.001	0.018	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
METHOXYCHLO	UG/L	0.001	0.001	0.001	0.001	0.001	0.013	0.011	0.015	0.028	0.012	0.003	0.002	0.056	0.028
TOXAPHENE	UG/L	0.005	0.015	0.001	0.001	0.001	0.040	0.148	0.001	0.050	0.032	0.003	1.000	0.010	0.014
ORG PHOSPH	UG/L	4.078	16.214	0.811	0.530	4.760	0.515	1.146	0.252	0.476	0.160	0.146	0.246	0.316	0.197
2-4-D	UG/L	1.250	0.259	0.113	0.100	4.063	1.463	0.658	0.183	1.796	0.894	0.210	0.122	0.867	0.834
PCB	UG/L	0.133	0.403	0.050	0.451	3.982	1.541	0.072	0.002	0.161	0.167	0.041	0.047	0.014	0.095
CARBAMATES	UG/L	0.001	0.001	0.018	0.031	0.046	0.011	0.121	0.027	0.152	0.001	0.001	0.041	0.001	0.012

SOUTHEAST STP INFLUENT ANALYSIS - CHLORINATED HYDROCARBONS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
LINDANE	UG/L	0.306	0.001	0.022
HPT-CL-EPOX	UG/L	0.007	0.001	0.002
DDE	UG/L	0.045	0.001	0.012
DDD	UG/L	0.037	0.001	0.007
DDT	UG/L	0.113	0.001	0.042
DIELDRIN	UG/L	0.025	0.001	0.005
TOT CL H.C.	UG/L	9.211	0.382	1.155
ALDRIN	UG/L	0.001	0.001	0.001
CHLORDANE	UG/L	0.035	0.001	0.007
ENDRIN	UG/L	1.000	0.001	0.004
HEPTACHLOR	UG/L	0.020	0.001	0.001
METHOXYCHLO	UG/L	0.056	0.001	0.010
TOXAPHENE	UG/L	1.000	0.001	0.158
ORG PHOSPH	UG/L	16.214	0.146	2.588
2-4-D	UG/L	4.063	0.100	0.551
PCB	UG/L	3.982	0.002	0.387
CARBAMATES	UG/L	0.152	0.001	0.018

NORTHPOINT STP INFLUENT ANALYSIS - HEAVY METALS

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ALUMINUM	UG/L	2,220	2,000	3,180	5,960	4,370	2,540	2,550	1,140	4,480	1,710	3,490	2,050	2,730	2,110
ANTIMONY	UG/L	30	50	30	70	20	20	100	100	40	50	80	120	50	80
ARSENIC	UG/L	5.4	5.7	4.0	3.9	11.3	3.2	4.1	3.7	11.5	8.7	2.3	4.9	0.7	1.6
BARIUM	UG/L	400	300	50	80	200	10	130	120	150	70	80	80	80	50
BERYLLIUM	UG/L	2.3	7.3	1.0	1.0	1.2	1.6	1.0	1.0	1.0	1.0	1.0	1.0	2.0	4.0
BISMUTH	UG/L	10	10	130	190	50	60	30	30	100	100	50	50	50	100
BORON	UG/L	220	320	450	740	440	640	590	610	160	410	500	270	410	1,260
CADMIUM	UG/L	6.0	4.0	6.0	5.2	3.0	7.0	68.0	12.0	7.4	2.6	68.0	12.0	1.0	11.0
CALCIUM	UG/L	23	26	23	28	21	25	24	30	19	25	21	26	19	26
CHROMIUM	UG/L	30	18	1,100	780	67	50	83	49	58	57	83	49	42	32
CR-6	UG/L	5.0	5.0	180.0	80.0	5.0	5.0	0.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0
COBALT	UG/L	7.0	10.0	1.0	1.0	5.0	5.0	0.1	0.1	5.0	5.0	1.0	1.0	14.0	5.0
COPPER	UG/L	410	260	320	480	3,200	3,100	140	170	800	250	140	170	220	200
CYANIDE	MG/L	50.000	0.060	0.008	0.005	0.013	0.023	0.005	0.030	1.830	0.148	0.008	0.040	0.030	0.068
FE -2	UG/L	150	80	200	100	100	100	150	130	200	400	100	150	300	400
GOLD	UG/L	8.0	6.0	1.0	1.0	5.0	5.0	0.1	0.1	5.0	5.0	1.0	1.0	3.0	5.0
IRON	UG/L	2,780	1,200	1,120	1,860	1,640	1,590	2,970	1,900	1,750	1,710	3,490	4,100	1,500	2,530
LEAD	UG/L	50	53	120	110	440	74	160	110	94	51	160	110	520	30
LITHIUM	UG/L	10	5	12	11	11	100	10	10	10	100	12	10	5	5
MAGNESIUM	UG/L	33.36	56.10	22.44	52.12	21.86	41.34	21.25	53.12	20.78	44.50	24.91	41.00	17.75	59.02
MANGANESE	UG/L	71	70	80	100	64	70	80	85	91	68	80	85	61	69
MERCURY	UG/L	0.48	0.68	0.70	0.82	0.88	0.72	1.46	1.34	1.08	0.48	0.70	0.68	1.06	0.84
MOLYBDENUM	UG/L	6	8	4	7	4	6	4	8	3	7	5	7	3	8
NICKEL	UG/L	16	13	37	37	73	19	34	6	64	27	100	20	14	170
PHOSPORUS	UG/L	7,200	5,900	7,100	6,000	7,200	6,900	6,300	5,300	8,500	6,100	8,400	6,700	8,500	6,300
POTASSIUM	MG/L	0.26	31.00	25.00	30.00	12.00	13.00	16.00	22.00	32.00	34.00	22.00	32.00	16.00	26.00
SELENIUM	UG/L	10	100	14	2	10	10	50	39	30	40	7	13	10	10
SILICON	UG/L	8,340	7,210	11,590	16,380	15,300	13,560	11,050	6,630	17,260	8,210	14,950	8,200	8,190	6,750
SILVER	UG/L	52	29	110	78	43	37	47	58	130	41	47	58	390	35
SODIUM	MG/L	360	475	100	220	290	440	390	510	100	320	220	320	110	320
STRONTIUM	UG/L	220	320	150	370	180	250	130	150	130	140	250	200	110	170
THALLIUM	UG/L	60	80	40	70	40	60	80	40	30	70	50	70	30	80
TIN	UG/L	11	8	11	15	10	60	8	8	6	7	15	7	5	8
TITANIUM	UG/L	130	36	78	61	49	30	55	49	68	60	20	20	24	32
TUNGSTEN	UG/L	110	200	70	150	70	120	20	150	60	140	100	140	50	170
URANIUM	UG/L	3.0	5.0	0.9	2.0	1.0	4.0	5.0	6.0	2.0	3.0	3.0	3.0	1.0	2.0
VANADIUM	UG/L	50	50	10	10	10	10	10	10	10	10	10	10	10	10
ZINC	UG/L	430	400	240	270	410	440	310	450	420	320	310	280	310	270
ZIRCONIUM	UG/L	130	110	121	104	214	159	214	196	241	251	117	80	173	146

NORTHPOINT STP INFLUENT ANALYSIS - HEAVY METALS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ALUMINUM	UG/L	5,960	1,140	2,501
ANTIMONY	UG/L	120	20	70
ARSENIC	UG/L	11.5	0.7	4.5
BARIUM	UG/L	400	10	101
BERYLLIUM	UG/L	7.3	1.0	2.4
BISMUTH	UG/L	190	10	77
BORON	UG/L	1,260	160	607
CADMIUM	UG/L	68.0	1.0	7.7
CALCIUM	UG/L	30	19	27
CHROMIUM	UG/L	1,100	16	148
CR-6	UG/L	180.0	0.5	15.7
COBALT	UG/L	14.0	0.1	3.9
COPPER	UG/L	3,200	140	661
CYANIDE	MG/L	50.000	0.005	0.053
FE -2	UG/L	400	80	194
GOLD	UG/L	8.0	0.1	3.3
IRON	UG/L	4,100	1,120	2,127
LEAD	UG/L	520	30	77
LITHIUM	UG/L	100	5	34
MAGNESIUM	UG/L	59,02	17,75	49,60
MANGANESE	UG/L	100	61	78
MERCURY	UG/L	1.46	0.48	0.79
MOLYBDENUM	UG/L	8	3	7
NICKEL	UG/L	170	6	42
PHOSPORUS	UG/L	8,500	5,300	6,171
POTASSIUM	MG/L	34.00	0.26	26.86
SELENIUM	UG/L	100	2	31
SILICON	UG/L	17,260	6,750	9,591
SILVER	UG/L	390	29	48
SODIUM	MG/L	510	100	372
STRONTIUM	UG/L	370	110	229
THALLIUM	UG/L	60	30	37
TIN	UG/L	60	5	16
TITANIUM	UG/L	130	20	41
TUNGSTEN	UG/L	200	20	153
URANIUM	UG/L	6.0	0.9	3.6
VANADIUM	UG/L	50	10	16
ZINC	UG/L	450	240	347
ZIRCONIUM	UG/L	251	80	149

NORTHPOINT STP INFLUENT ANALYSIS - PHYSICAL - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
COLOR	UNITS	138	96	90	60	125	80	90	60	105	60	90	70	75	60
CONDUCT.	U-MHO	1,620	2,000	882	1,670	100	1,670	1,070	1,670	938	1,710	1,250	1,880	789	2,001
FLOATABLES	MG/L	3.2	4.6	10.0	6.9	5.2	5.3	2.4	3.1	4.0	3.5	2.8	3.5	7.8	2.6
ODOR-RM T	TH-NO.	1134.0	537.5	4656.0	4310.0	6750.0	7600.0	6792.5	6141.5	2600.0	4915.0	2860.0	4656.5	2461.0	6300.0
SETTLEABLE	MG/L	12.0	3.1	18.0	6.0	9.0	4.0	4.5	9.0	3.0	4.0	4.0	7.0	4.0	2.0
TOT DIS SOL	MG/L	745.0	1010.0	470.0	931.0	507.0	825.0	554.0	790.0	512.0	810.0	596.0	869.0	386.0	933.5
TOT SOLIDS	MG/L	269	1,160	950	1,080	734	967	716	990	665	989	731	1,077	547	1,041
TOT SUS MAT	MG/L	269.0	145.0	480.0	148.0	227.0	142.0	162.0	210.0	153.0	179.0	135.0	208.0	161.1	107.1
TOT VOL SOL	MG/L	493	339	533	344	314	246	308	310	320	316	256	338	239	230
TURBIDITY	JTU	198	174	240	135	240	135	145	125	115	120	125	120	110	70
VOL SUS MAT	MG/L	231.0	135.0	422.0	134.0	200.0	129.0	138.0	180.0	141.0	157.0	125.0	186.0	146.4	100.5
TEMPERATURE	DEG-C	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	21.5	22.0	21.0	21.0	21.5	22.0

4/16/73 - 4/28/73

NORTHPOINT STP INFLUENT ANALYSIS - PHYSICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
COLOR	UNITS	138	60	69
CONDUCT.	U-MHO	2,001	100	1,800
FLOATABLES	MG/L	10.0	2.4	4.2
ODOR-RM T	TH-NO.	24,915.0	537.5	7,780.1
SETTLEABLE	MG/L	18.0	2.0	5.0
TOT DIS SOL	MG/L	1,010.0	386.0	881.2
TOT SOLIDS	MG/L	1,160	269	1,043
TOT SUS MAT	MG/L	480.0	107.1	162.7
TOT VOL SOL	MG/L	533	230	303
TURBIDITY	JTU	240	70	126
VOL SUS MAT	MG/L	422.0	100.5	145.9
TEMPERATURE	DEG-C	22.0	21.0	21.9

NORTHPOINT STP INFLUENT ANALYSIS - CHEMICAL AND BIOCHEMICAL - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ACID(CACO3)	MG/L	26.1	27.0	20.0	16.0	38.0	26.4	1.0	23.0	36.0	31.0	18.0	24.0	12.0	12.0
ALKA(CACO3)	MG/L	160	156	157	142	151	148	209	145	134	140	155	138	145	133
BOD(5 DAY)	MG/L	222	211	166	150	217	206	135	174	282	219	186	130	152	140
BOD(ULTIM)	MG/L	620	460	260	320	830	380	220	340	930	500	380	330	370	370
BROMIDE	MG/L	0.10	0.10	0.10	0.10	0.10	0.15	0.45	2.60	0.10	0.10	0.10	0.35	0.10	1.40
CO2	MG/L	23.00	24.00	17.00	14.00	34.00	23.00	1.00	20.00	32.00	27.00	16.00	21.00	1.06	10.20
CHLORIDE	MG/L	249	389	122	353	146	334	138	338	81	403	212	378	80	370
COD	MG/L	696	672	566	363	471	384	474	453	674	681	404	388	423	363
DIS OXY	MG/L	1.12	2.17	1.20	3.70	0.68	2.00	1.50	2.10	1.20	2.00	0.50	4.30	1.60	2.70
FLUORIDE	MG/L	1.50	1.00	1.28	1.08	1.52	1.20	1.28	1.18	1.40	1.10	1.10	0.82	0.84	0.84
IODIDE	MG/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.010	0.010	0.001	0.001	0.032	0.003
OIL-GR(TOT)	MG/L	136.1	220.4	47.0	56.0	65.1	121.3	20.0	43.0	84.0	88.0	51.0	66.0	39.0	74.0
PH	UNIT	7.8	9.3	7.7	8.0	7.9	6.5	9.3	9.4	7.4	8.7	7.5	9.6	7.4	7.9
PHENOLS	MG/L	0.100	0.050	0.205	0.056	0.040	0.040	0.085	0.072	0.055	0.035	0.065	0.030	0.025	0.020
SULFATE	MG/L	66	84	28	68	22	75	39	78	33	76	56	83	34	80
SULFIDE	MG/L	0.40	0.30	0.80	0.60	0.32	0.27	6.80	0.61	0.48	0.53	0.37	0.34	0.42	0.40
SULFITE	MG/L	2.9	4.0	2.4	2.3	3.7	2.3	3.5	2.5	3.7	2.0	2.2	2.6	2.3	2.3
SURFACTANTS	MG/L	4.3	4.6	7.6	7.5	4.3	9.6	4.9	7.3	6.3	5.4	8.0	7.1	5.5	5.1
TOT HARD	MG/L	160	220	120	140	110	195	120	200	110	200	190	210	100	220
TOT ORG CAR	MG/L	132	140	103	124	116	110	114	88	108	106	126	116	90	67

4/16/73 - 4/28/73

NORTHPOINT STP INFLUENT ANALYSIS - CHEMICAL AND BIOCHEMICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ACID(CACO3)	MG/L	38.0	1.0	22.8
ALKA(CACO3)	MG/L	209	133	143
BOD(5 DAY)	MG/L	282	130	176
BOD(ULTIM)	MG/L	930	220	386
BROMIDE	MG/L	2.60	0.10	0.69
CO2	MG/L	34.00	1.00	19.89
CHLORIDE	MG/L	403	80	366
COD	MG/L	696	363	472
DIS OXY	MG/L	4.30	0.50	2.71
FLUORIDE	MG/L	1.52	0.82	1.03
IODIDE	MG/L	0.032	0.001	0.003
OIL-GR(TOT)	MG/L	220.4	20.0	95.5
PH	UNIT	9.6	7.4	8.8
PHENOLS	MG/L	0.205	0.020	0.043
SULFATE	MG/L	84	22	78
SULFIDE	MG/L	6.80	0.27	0.44
SULFITE	MG/L	4.0	2.0	2.6
SURFACTANTS	MG/L	9.6	4.3	6.7
TOT HARD	MG/L	220	100	198
TOT ORG CAR	MG/L	140	67	107

NORTHPOINT STP - INFLUENT ANALYSIS - NUTRIENTS - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
AMMONIA-N	MG/L	18.0	12.0	18.0	14.0	12.0	8.8	14.0	12.0	12.0	10.0	30.0	20.0	14.0	9.6
NITRATE-N	MG/L	0.59	0.15	0.05	0.27	0.16	0.17	0.26	0.24	0.04	0.10	0.34	0.16	0.15	0.26
NITRITE-N	MG/L	0.01	0.01	0.01	0.07	0.01	0.08	0.84	0.01	0.02	0.01	0.01	0.01	0.01	0.16
ORGANIC-N	MG/L	14.0	33.0	20.0	28.0	30.0	7.2	7.4	7.0	31.0	12.0	14.0	15.0	7.5	39.0
TOTAL N	MG/L	32	45	38	42	42	16	21	19	43	22	44	35	22	49
ORTHO-P	MG/L	4.0	3.2	4.4	3.7	4.6	3.7	3.8	3.4	6.3	3.4	6.2	4.7	4.6	3.2
TOTAL-P	MG/L	7.2	5.9	7.1	6.0	7.2	6.9	6.3	5.3	8.5	6.1	8.4	6.7	8.5	6.3

4/16/73 - 4/28/73

NORTHPOINT STP - INFLUENT ANALYSIS - NUTRIENTS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
AMMONIA-N	MG/L	30.0	8.8	12.3
NITRATE-N	MG/L	0.59	0.04	0.19
NITRITE-N	MG/L	0.84	0.01	0.05
ORGANIC-N	MG/L	39.0	7.0	20.2
TOTAL N	MG/L	49	16	33
ORTHO-P	MG/L	6.3	3.2	3.6
TOTAL-P	MG/L	8.5	5.3	6.2

NORTHPOINT STP - INFLUENT ANALYSIS - BIOASSAYS - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
TLM-24 HR	%	62			63	65				35	86	61	88	92	78
TLM-48 HR	%	62			63	65	10			35	86	61	88	90	78
TLM-96 HR	%	62			61	65	96	83		35	86	61	88	86	78
SURVIVAL-24	%	0	100	100	0	0	80	80	100	0	0	0	10	30	0
SURVIVAL-48	%	0	100	100	0	0	50	60	90	0	0	0	10	20	0
SURVIVAL-96	%	0	100	80	0	0	40	0	90	0	0	0	10	0	0
TOXICITY	UNITS	1.61	0.00	0.77	1.64	1.54	1.04	1.20	0.59	2.86	1.16	1.64	1.14	1.16	1.28

4/16/73 - 4/28/73

NORTHPOINT STP - INFLUENT ANALYSIS - BIOASSAYS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
TLM-24 HR	%	92	35	79
TLM-48 HR	%	90	10	65
TLM-96 HR	%	96	35	82
SURVIVAL-24	%	100	0	41
SURVIVAL-48	%	100	0	36
SURVIVAL-96	%	100	0	34
TOXICITY	UNITS	2.86	0.00	0.98

NORTHPOINT STP - INFLUENT ANALYSIS - RADIOACTIVE SUBSTANCES - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
GROSS ALPHA	PC/L	3	25	4	26	4	9	17	28	5	11	6	10	5	7
GROSS BETA	PC/L	19	28	19	46	18	32	21	32	19	42	23	36	16	28
RADIUM 226	PC/L	0.70	0.10	0.14	0.10	0.08	0.03	0.20	0.11	0.04	0.10	0.10	0.10	0.10	0.12
STRONT. 90	PC/L	0.5	2.0	0.5	0.5	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

4/16/73 - 4/28/73

NORTHPOINT STP - INFLUENT ANALYSIS - RADIOACTIVE SUBSTANCES

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
GROSS ALPHA	PC/L	28	3	17
GROSS BETA	PC/L	46	16	35
RADIUM 226	PC/L	0.70	0.03	0.09
STRONT. 90	PC/L	2.0	0.5	0.8

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
LINDANE	UG/L	0.004	0.002	0.001	0.009	0.017	0.009	0.074	0.001	0.018	0.025	0.021	0.100	0.047	0.037
HPT-CL-EPOX	UG/L	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.002	0.001	0.001	0.001	0.002	0.039	0.001
DDE	UG/L	0.002	0.002	0.001	0.021	0.015	0.011	0.011	0.018	0.009	0.011	0.012	0.006	0.001	0.001
DDD	UG/L	0.001	0.001	0.001	0.001	0.009	0.011	0.001	0.001	0.091	0.010	0.016	0.009	0.041	0.021
DDT	UG/L	0.013	0.008	0.001	0.001	0.104	0.050	0.080	0.067	0.047	0.064	0.080	0.038	0.055	0.067
DIELDRIN	UG/L	0.002	0.002	0.024	0.001	0.012	0.012	0.001	0.001	0.001	0.001	0.001	0.001	0.022	0.001
TOT CL H.C.	UG/L	0.651	0.770	0.495	0.641	1.045	0.800	0.061	0.704	0.952	1.270	0.407	0.219	1.090	0.783
ALDRIN	UG/L	0.001	0.001	0.001	0.009	0.035	0.022	0.001	0.001	0.011	0.008	0.001	0.001	0.001	0.001
CHLORDANE	UG/L	0.020	0.001	0.001	0.066	0.161	0.058	0.001	0.001	0.021	0.034	0.001	0.010	0.156	0.001
ENDRIN	UG/L	0.002	0.001	0.011	0.002	0.011	0.001	0.003	0.006	0.001	0.001	0.006	0.003	0.001	0.001
HEPTACHLOR	UG/L	0.001	0.200	0.020	0.001	0.045	0.001	0.006	0.019	0.029	0.001	0.001	0.001	0.047	0.031
METHOXYCHLO	UG/L	0.001	0.001	0.001	0.261	0.001	0.004	0.001	0.015	0.002	0.010	0.003	0.001	0.001	0.008
TOXAPHENE	UG/L	0.005	0.001	0.001	0.001	0.030	0.001	0.080	0.020	0.010	0.014	0.008	0.001	0.001	0.001
ORG PHOSPH	UG/L	7.306	7.600	1.362	0.085	0.437	0.515	2.087	0.012	0.480	0.913	0.716	0.279	0.592	0.151
2-4-D	UG/L	0.425	0.286	0.225	0.412	1.241	0.799	0.692	0.350	0.465	0.401	0.681	0.175	0.212	0.794
PCB	UG/L	0.304	0.433	0.334	0.195	0.550	0.566	0.021	0.097	0.028	0.662	0.101	0.067	1.072	0.916
CARBAMATES	UG/L	0.016	0.001	0.111	0.012	0.015	0.012	0.561	0.341	0.031	0.015	0.019	0.001	0.190	0.071

4/16/73 - 4/28/73

NORTHPOINT STP INFLUENT ANALYSIS - CHLORINATED HYDROCARBONS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
LINDANE	UG/L	0.100	0.001	0.026
HPT-CL-EPOX	UG/L	0.039	0.001	0.001
DDE	UG/L	0.021	0.001	0.010
DDD	UG/L	0.091	0.001	0.008
DDT	UG/L	0.104	0.001	0.042
DIELDRIN	UG/L	0.024	0.001	0.003
TOT CL H.C.	UG/L	1.270	0.061	0.741
ALDRIN	UG/L	0.035	0.001	0.006
CHLORDANE	UG/L	0.161	0.001	0.024
ENDRIN	UG/L	0.011	0.001	0.002
HEPTACHLOR	UG/L	0.200	0.001	0.036
METHOXYCHLO	UG/L	0.261	0.001	0.043
TOXAPHENE	UG/L	0.080	0.001	0.006
ORG PHOSPH	UG/L	7.600	0.012	1.365
2-4-D	UG/L	1.241	0.175	0.460
PCB	UG/L	1.072	0.021	0.419
CARBAMATES	UG/L	0.561	0.001	0.065

RICHMOND-SUNSET STP INFLUENT ANALYSIS - HEAVY METALS

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ALUMINUM	UG/L	1,030	1,220	570	1,560	1,890	2,380	1,250	1,140	3,240	960	840	670	2,190	1,860
ANTIMONY	UG/L	10	10	30	10	20	10	50	50	40	30	80	50	50	30
ARSENIC	UG/L	4.3	3.7	1.6	2.5	3.7	7.0	3.2	1.8	3.3	4.3	4.9	3.5	4.1	3.7
BARIUM	UG/L	200	200	80	80	20	20	80	120	150	100	110	50	90	50
BERYLLIUM	UG/L	2.7	2.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.0	2.0
BISMUTH	UG/L	10	10	100	40	20	40	30	30	50	50	30	30	50	50
BORON	UG/L	100	120	110	360	150	260	290	390	170	240	290	220	330	190
CADMIUM	UG/L	4.0	2.0	1.0	1.0	1.0	1.0	5.6	1.0	0.9	0.6	6.0	1.0	2.0	1.0
CALCIUM	UG/L	19	16	16	16	18	16	18	20	16	15	16	16	15	16
CHROMIUM	UG/L	25	17	10	17	4	8	4	11	15	110	4	11	9	8
CR-6	UG/L	5	5	5	5	5	5	5	5	5	5	5	5	5	5
COBALT	UG/L	2.0	2.0	1.0	1.0	5.0	5.0	0.1	0.1	5.0	5.0	1.0	1.0	14.0	5.0
COPPER	UG/L	170	170	120	90	100	76	80	86	89	78	80	880	130	78
CYANIDE	MG/L	0.050	0.050	0.008	0.008	0.005	0.010	0.005	0.005	0.055	0.045	0.005	0.005	0.005	0.020
FE -2	UG/L	100	100	200	150	100	100	100	50	100	300	250	200	100	100
GOLD	UG/L	8.0	7.0	1.0	1.0	5.0	5.0	0.1	0.1	3.0	5.0	1.0	1.0	8.0	8.0
IRON	UG/L	1,650	2,070	540	720	1,130	1,300	1,660	1,630	1,300	840	1,690	1,340	1,420	930
LEAD	UG/L	180	140	52	58	64	66	32	92	58	55	32	92	74	47
LITHIUM	UG/L	5	5	10	10	4	5	10	10	8	8	10	8	5	5
MAGNESIUM	UG/L	14.42	15.84	5.36	16.79	13.24	12.98	13.51	22.84	13.63	15.56	14.47	14.59	15.97	16.32
MANGANESE	UG/L	84	99	40	40	52	87	37	42	39	34	37	42	52	35
MERCURY	UG/L	0.52	0.78	0.44	0.68	0.72	0.24	1.00	1.52	0.40	0.86	0.68	0.96	1.18	1.08
MOLYBDENUM	UG/L	2	2	1	2	2	2	2	3	2	2	2	2	2	2
NICKEL	UG/L	21	24	4	17	57	22	17	3	54	12	24	34	180	12
PHOSPORUS	UG/L	9,500	9,000	8,800	7,900	7,500	8,000	7,400	6,300	8,300	8,000	12,500	8,900	11,700	9,300
POTASSIUM	MG/L	15	13	24	21	6	5	14	12	25	22	17	13	18	17
SELENIUM	UG/L	10	10	6	8	10	10	10	40	50	20	8	8	10	10
SILICON	UG/L	6,180	8,530	3,440	8,390	6,600	7,570	4,990	3,260	12,980	5,750	7,230	4,940	9,850	9,320
SILVER	UG/L	64	37	18	18	13	28	15	19	22	18	15	19	26	19
SODIUM	MG/L	130	140	70	85	170	190	310	350	50	60	105	90	60	80
STRONTIUM	UG/L	100	120	31	96	56	87	62	98	90	96	48	130	66	70
THALLIUM	UG/L	20	20	10	20	20	20	20	30	20	20	20	20	200	200
TIN	UG/L	10	7	2	5	19	6	10	3	9	5	5	4	7	5
TITANIUM	UG/L	180	64	40	32	49	81	20	40	56	44	20	20	44	28
TUNGSTEN	UG/L	40	50	20	50	40	40	40	70	40	5	50	40	40	50
URANIUM	UG/L	9	10	3	2	6	2	5	6	4	3	1	3	1	5
VANADIUM	UG/L	50	50	10	10	10	10	10	10	10	10	10	10	10	10
ZINC	UG/L	320	300	240	160	320	270	300	230	240	200	450	240	250	200
ZIRCONIUM	UG/L	220	110	80	287	154	186	167	196	270	223	131	113	127	177

RICHMOND-SUNSET STP INFLUENT ANALYSIS - HEAVY METALS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ALUMINUM	UG/L	3,240	570	1,399
ANTIMONY	UG/L	80	10	27
ARSENIC	UG/L	7.0	1.6	3.8
BARIUM	UG/L	200	20	89
BERYLLIUM	UG/L	4.0	1.0	1.4
BISMUTH	UG/L	100	10	36
BORON	UG/L	390	100	254
CADMIUM	UG/L	6.0	0.6	1.1
CALCIUM	UG/L	20	15	16
CHROMIUM	UG/L	110	4	26
CR-6	UG/L	5	5	5
COBALT	UG/L	14.0	0.1	2.7
COPPER	UG/L	880	76	209
CYANIDE	MG/L	0.055	0.005	0.020
FE -2	UG/L	300	50	143
GOLD	UG/L	8.0	0.1	3.9
IRON	UG/L	2,070	540	1,261
LEAD	UG/L	180	32	79
LITHIUM	UG/L	10	4	7
MAGNESIUM	UG/L	22,84	5.36	16,42
MANGANESE	UG/L	99	34	54
MERCURY	UG/L	1.52	0.24	0.87
MOLYBDENUM	UG/L	3	1	2
NICKEL	UG/L	180	3	18
PHOSPORUS	UG/L	12,500	6,300	8,200
POTASSIUM	MG/L	25	5	15
SELENIUM	UG/L	50	6	15
SILICON	UG/L	12,980	3,260	6,823
SILVER	UG/L	64	13	23
SODIUM	MG/L	350	50	142
STRONTIUM	UG/L	130	31	100
THALLIUM	UG/L	200	10	47
TIN	UG/L	19	2	5
TITANIUM	UG/L	180	20	44
TUNGSTEN	UG/L	70	5	44
URANIUM	UG/L	10	1	4
VANADIUM	UG/L	50	10	16
ZINC	UG/L	450	160	229
ZIRCONIUM	UG/L	287	80	185

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
COLOR	UNITS	192	156	110	80	165	90	115	100	100	125	120	100	150	115
CONDUCT.	U-MHO	1,360	819	667	690	834	789	750	833	909	769	1,150	741	789	625
FLOATABLES	MG/L	2.8	39.0	7.8	11.0	6.1	4.6	17.0	9.8	6.4	7.6	30.0	45.0	9.5	5.3
ODOR-RM T	TH-NO.	671.0	320.5	2270.5	5347.5	5150.0	0000.0	458.0	1789.5	8845.0	8230.0	2309.0	2464.5	664.0	1569.0
SETTLEABLE	MG/L	11.0	8.5	10.0	5.5	11.0	12.0	12.0	7.0	6.0	10.0	19.0	6.5	13.0	22.0
TOT DIS SOL	MG/L	334	370	315	369	349	338	291	449	343	380	385	183	326	329
TOT SOLIDS	MG/L	588	621	521	524	558	618	540	636	534	605	686	546	1,373	504
TOT SUS MAT	MG/L	254	251	206	155	209	280	251	186	190	224	300	183	1,047	174
TOT VOL SOL	MG/L	390	390	266	249	284	350	310	266	310	334	381	274	1,049	243
TURBIDITY	JTU	198	180	200	145	139	170	155	140	105	195	145	115	175	120
VOL SUS MAT	MG/L	230.0	236.0	190.0	149.0	94.0	247.0	233.0	174.0	175.0	209.0	264.0	171.0	1017.0	164.3
TEMPERATURE	DEG-C	21.0	21.8	21.2	21.8	19.8	20.3	20.7	21.2	20.7	21.4	21.2	21.9	21.3	21.9

RICHMOND-SUNSET STP INFLUENT ANALYSIS - PHYSICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
COLOR	UNITS	192	80	109
CONDUCT.	U-MHO	1,360	625	752
FLOATABLES	MG/L	45.0	2.8	17.5
ODOR-RM T	TH-NO.	38,230.0	320.5	8,531.6
SETTLEABLE	MG/L	22.0	5.5	10.2
TOT DIS SOL	MG/L	449	183	345
TOT SOLIDS	MG/L	1,373	504	579
TOT SUS MAT	MG/L	1,047	155	208
TOT VOL SOL	MG/L	1,049	243	301
TURBIDITY	JTU	200	105	152
VOL SUS MAT	MG/L	1,017.0	94.0	192.9
TEMPERATURE	DEG-C	21.9	19.8	21.5

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
ACID(CACO3)	MG/L	23.0	22.7	23.0	22.0	37.0	24.2	17.0	14.0	9.6	14.0	22.0	20.0	26.0	21.0
ALKA(CACO3)	MG/L	203	149	186	138	189	143	189	206	178	145	179	142	167	139
BOD(5 DAY)	MG/L	196	199	156	128	191	142	185	165	210	165	189	169	166	157
BOD(ULTIM)	MG/L	650	610	310	300	860	500	420	290	770	770	420	300	580	460
BROMIDE	MG/L	0.10	0.10	0.10	0.10	0.10	0.10	0.45	0.10	0.10	0.10	0.10	0.10	0.10	0.10
CO2	MG/L	20.2	28.0	20.0	19.0	32.0	21.0	15.0	12.0	8.4	12.0	19.0	18.0	23.0	1.8
CHLORIDE	MG/L	244.0	88.3	67.0	85.0	107.0	82.0	49.0	130.0	106.0	104.0	82.0	94.0	62.0	75.0
COD	MG/L	2,480	816	520	628	1,450	692	640	420	1,150	425	600	558	601	483
DIS OXY	MG/L	0.40	2.85	0.50	4.10	0.70	3.75	0.60	3.20	0.10	2.45	0.10	3.20	1.40	3.60
FLUORIDE	MG/L	0.82	0.80	0.71	0.84	0.94	0.98	1.00	1.38	0.86	1.00	0.82	0.82	0.70	0.70
IODIDE	MG/L	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.046	0.018	0.001	0.001	0.032	0.004
OIL-GR(TOT)	MG/L	77	117	48	17	56	52	47	23	56	57	72	66	48	106
PH	UNIT	9.20	9.20	8.25	8.50	7.90	8.20	8.20	8.00	8.10	8.20	8.10	8.50	7.60	8.00
PHENOLS	MG/L	0.115	0.065	0.065	0.230	0.410	0.040	0.053	0.078	0.120	0.080	0.045	0.045	0.038	0.038
SULFATE	MG/L	28	41	18	28	29	17	16	32	28	32	37	33	23	32
SULFIDE	MG/L	0.40	0.40	0.70	0.60	0.28	0.26	0.50	0.50	0.40	0.66	0.37	0.37	1.30	0.64
SULFITE	MG/L	1.6	2.3	2.8	2.2	4.1	3.1	2.4	2.4	1.8	1.6	2.2	2.0	2.6	2.3
SURFACTANTS	MG/L	4.9	9.0	6.0	10.5	5.8	11.0	4.6	8.3	6.2	9.2	11.4	11.5	8.0	8.3
TOT HARD	MG/L	140	100	70	70	100	85	90	100	120	100	80	90	70	90
TOT ORG CAR	MG/L	170	140	129	98	148	101	113	99	99	84	146	96	134	91

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RICHMOND-SUNSET INFLUENT ANALYSIS - CHEMICAL AND BIOCHEMICAL

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
ACID(CACO3)	MG/L	37.0	9.6	19.7
ALKA(CACO3)	MG/L	206	138	152
BOD(5 DAY)	MG/L	210	128	161
BOD(ULTIM)	MG/L	860	290	461
BROMIDE	MG/L	0.45	0.10	0.10
CO2	MG/L	32.0	1.8	16.0
CHLORIDE	MG/L	244.0	49.0	94.0
COD	MG/L	2,480	420	575
DIS OXY	MG/L	4.10	0.10	3.31
FLUORIDE	MG/L	1.38	0.70	0.93
IODIDE	MG/L	0.046	0.001	0.004
OIL-GR(TOT)	MG/L	117	17	63
PH	UNIT	9.20	7.60	8.37
PHENOLS	MG/L	0.410	0.038	0.082
SULFATE	MG/L	41	16	31
SULFIDE	MG/L	1.30	0.26	0.49
SULFITE	MG/L	4.1	1.6	2.3
SURFACTANTS	MG/L	11.5	4.6	9.7
TOT HARD	MG/L	140	70	91
TOT ORG CAR	MG/L	170	84	101

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
AMMONIA-N	MG/L	31.0	18.0	34.0	19.0	22.0	13.4	30.0	15.0	25.0	15.0	39.0	33.0	18.0	16.0
NITRATE-N	MG/L	0.43	0.98	0.07	0.05	0.30	0.12	0.42	0.43	0.14	0.10	0.10	0.21	0.26	0.20
NITRITE-N	MG/L	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.04	0.04	0.01	0.01	0.02	0.02
ORGANIC-N	MG/L	13.0	17.0	71.0	36.0	16.0	20.6	29.0	5.4	37.0	38.0	26.0	20.0	24.0	22.0
TOTAL N	MG/L	44	35	105	55	38	34	50	21	62	53	65	52	42	38
ORTHO-P	MG/L	9.5	5.5	6.4	5.0	6.1	4.7	6.0	4.7	6.6	5.6	9.9	6.7	8.8	5.9
TOTAL-P	MG/L	9.1	9.0	8.8	7.9	7.5	8.0	7.4	6.3	8.3	8.0	12.5	8.9	11.7	9.3

RICHMOND-SUNSET STP INFLUENT ANALYSIS - NUTRIENTS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
AMMONIA-N	MG/L	39.0	13.4	18.5
NITRATE-N	MG/L	0.98	0.05	0.30
NITRITE-N	MG/L	0.04	0.01	0.02
ORGANIC-N	MG/L	71.0	5.4	22.7
TOTAL N	MG/L	105	21	41
ORTHO-P	MG/L	9.9	4.7	5.4
TOTAL-P	MG/L	12.5	6.3	8.2

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
TLM-24 HR	%	87	70	70		86	92			86	90	79	86	81	86
TLM-48 HR	%	85	67	70		86	88	86	100	64	88	63	81	63	81
TLM-96 HR	%	85	61	70		84	87	86	100	61	88	58	75	61	75
SURVIVAL-24	%	0	40	0	90	0	30	60	70	0	20	0	0	0	0
SURVIVAL-48	%	0	10	0	80	0	10	0	50	0	10	0	0	0	0
SURVIVAL-96	%	0	0	0	70	0	0	0	50	0	10	0	0	0	0
TOXICITY	UNITS	1.18	1.64	1.43	0.87	1.19	1.15	1.15	1.00	1.64	1.14	1.72	1.33	1.64	1.33

RICHMOND-SUNSET INFLUENT ANALYSIS - BIOASSAYS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
TLM-24 HR	%	92	70	85
TLM-48 HR	%	100	63	84
TLM-96 HR	%	100	58	81
SURVIVAL-24	%	90	0	36
SURVIVAL-48	%	80	0	23
SURVIVAL-96	%	70	0	19
TOXICITY	UNITS	1.72	0.87	1.21

RICHMOND-SUNSET STP INFLUENT ANALYSIS - RADIOACTIVE SUBSTANCES - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
GROSS ALPHA	PC/L	2	4	2	3	3	3	3	5	4	4	3	3	3	3
GROSS BETA	PC/L	18	24	11	13	13	20	40	18	22	24	18	15	20	17
RADIUM 226	PC/L	0.03	0.20	0.10	0.14	0.05	0.04	0.04	0.20	0.10	0.10	0.10	0.10	0.09	0.10
STRONT. 90	PC/L	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5

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RICHMOND-SUNSET STP INFLUENT ANALYSIS - RADIOACTIVE SUBSTANCES

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
GROSS ALPHA	PC/L	5	2	4
GROSS BETA	PC/L	40	11	19
RADIUM 226	PC/L	0.20	0.03	0.13
STRONT. 90	PC/L	1.0	0.5	0.6

RICHMOND-SUNSET STP INFLUENT ANALYSIS - CHLORINATED HYDROCARBONS - 1973

		MON 4/16		TUES 4/24		WED 4/18		THUR 4/26		FRI 4/20		SAT 4/28		SUN 4/22	
CONSTITUENT	UNIT	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP	GRAB	COMP
LINDANE	UG/L	0.003	0.002	0.012	0.031	0.001	0.038	0.009	0.064	0.043	0.046	0.023	0.036	0.001	0.045
HPT-CL-EPOX	UG/L	0.001	0.001	0.001	0.211	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.905	0.045
DDE	UG/L	0.002	0.003	0.001	0.001	0.021	0.001	0.021	0.001	0.010	0.001	0.001	0.001	0.001	0.001
DDD	UG/L	0.001	0.003	0.001	0.001	0.011	0.010	0.017	0.031	0.057	0.001	0.009	0.001	0.001	0.034
DDT	UG/L	0.380	0.012	0.001	0.150	0.030	0.038	0.800	0.112	0.067	0.047	0.050	0.079	0.016	0.073
DIELDRIN	UG/L	0.002	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.020
TOT CL H.C.	UG/L	0.542	0.655	1.486	1.002	0.175	0.545	1.038	0.603	1.678	0.689	0.455	0.573	1.876	1.016
ALDRIN	UG/L	0.040	0.004	0.001	0.001	0.014	0.008	0.001	0.001	0.020	0.005	0.001	0.001	0.047	0.017
CHLORDANE	UG/L	0.021	0.031	0.050	0.122	0.063	0.075	0.050	0.001	0.035	0.128	0.042	0.196	0.114	0.157
ENDRIN	UG/L	0.001	0.002	0.001	0.001	0.001	0.002	0.003	0.001	0.001	0.001	0.001	0.001	0.062	0.001
HEPTACHLOR	UG/L	0.001	0.008	0.014	0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.001	0.001	0.001
METHOXYCHLO	UG/L	0.001	0.001	0.058	0.001	0.006	0.001	0.008	0.015	0.008	0.011	0.007	0.007	0.009	0.026
TOXAPHENE	UG/L	0.013	0.004	0.001	0.001	0.014	0.004	0.001	0.020	0.001	0.007	0.001	0.001	0.001	0.008
ORG PHOSPH	UG/L	3.981	6.408	0.850	1.910	0.320	0.796	1.568	0.995	0.754	0.676	0.620	0.655	0.066	0.001
2-4-D	UG/L	1.379	0.317	0.200	0.188	0.345	0.976	0.267	0.057	0.362	0.653	0.322	0.122	0.277	0.168
PCB	UG/L	0.195	0.308	1.269	0.351	0.013	0.335	0.028	0.016	0.891	0.095	0.085	0.015	1.560	1.000
CARBAMATES	UG/L	0.009	0.001	0.109	0.136	0.111	0.001	0.455	0.321	0.001	0.054	0.053	0.001	0.095	0.131

4/16/73 - 4/28/73

RICHMOND-SUNSET STP INFLUENT ANALYSIS - CHLORINATED HYDROCARBONS

CONSTITUENT	UNIT	HIGH	LOW	AVG COMP
LINDANE	UG/L	0.064	0.001	0.037
HPT-CL-EPOX	UG/L	0.905	0.001	0.037
DDE	UG/L	0.021	0.001	0.001
DDD	UG/L	0.057	0.001	0.012
DDT	UG/L	0.800	0.001	0.073
DIELDRIN	UG/L	0.020	0.001	0.004
TOT CL H.C.	UG/L	1.876	0.175	0.726
ALDRIN	UG/L	0.047	0.001	0.005
CHLORDANE	UG/L	0.196	0.001	0.101
ENDRIN	UG/L	0.062	0.001	0.001
HEPTACHLOR	UG/L	0.014	0.001	0.003
METHOXYCHLO	UG/L	0.058	0.001	0.009
TOXAPHENE	UG/L	0.020	0.001	0.006
ORG PHOSPH	UG/L	6.408	0.001	1.634
2-4-D	UG/L	1.379	0.057	0.354
PCB	UG/L	1.560	0.013	0.303
CARBAMATES	UG/L	0.455	0.001	0.092

SAN FRANCISCO PILOT PLANT STUDY
SOUTHEAST INFLUENT – APRIL 1973

	MON.–16		TUE.–24		WED.–18		THU.–26		FRI.–20		SAT.–28		SUN.–22	
TIME	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO
0030	7.3	1.5	7.65	2.5	7.6	2.8	7.0	1.6	6.5	2.9	9.0	0.8	7.4	1.4
0100	7.35	1.7	7.5	2.3	6.0	2.9	6.6	2.0	7.1	2.9	8.6	0.6	7.3	2.0
0130	7.3	1.4	7.5	2.6	5.6	3.0	6.9	2.4	7.3	2.8	8.9	0.3	7.3	1.9
0200	7.35	1.3	7.5	2.4	7.6	2.2	6.8	2.0	7.6	3.0	9.05	0.3	7.4	2.6
0230	7.45	1.9	7.5	2.5	7.2	2.7	6.8	1.7	7.6	2.4	9.9	0.8	7.3	2.8
0300	7.3	2.1	7.4	2.8	7.35	2.6	7.1	2.2	7.6	2.9	8.3	0.4	7.4	2.7
0330	7.78	2.5	7.5	2.6	7.4	2.8	7.0	1.5	7.4	2.1	9.65	0.2	7.5	2.9
0400	7.92	1.5	7.4	2.6	7.1	2.8	7.2	2.1	–	3.1	8.4	0.9	7.4	2.1
0430	7.9	1.4	6.8	3.0	6.8	3.0	7.2	1.9	–	3.4	7.95	0.8	7.3	2.3
0500	8.05	1.5	7.1	2.8	7.3	2.9	7.15	1.7	–	3.8	6.85	0.7	7.4	2.3
0530	7.9	2.2	6.8	2.8	7.3	2.8	7.0	2.3	–	3.0	7.0	0.4	7.5	3.0
0600	6.8	3.5	6.8	2.6	7.7	2.2	7.1	1.6	–	2.6	6.9	0.9	7.4	2.6
0630	7.0	3.1	7.5	2.4	7.7	2.6	7.0	1.4	–	3.4	7.1	0.8	7.4	2.3
0700	7.35	3.0	7.05	2.9	7.9	2.4	7.1	1.8	–	3.3	7.3	0.9	7.0	2.1
0730	7.5	2.4	6.3	2.7	8.2	1.3	7.0	1.5	–	2.8	7.05	0.7	7.1	1.2
0800	7.9	1.5	6.6	1.2	7.85	1.2	7.1	0.7	6.8	2.0	6.7	0.2	7.2	1.5
0830	7.65	1.3	7.5	0.9	8.7	1.4	7.6	0.9	7.6	1.2	7.25	0.3	6.9	1.4
0900	7.8	1.4	7.7	0.7	7.7	3.0	7.5	0.3	7.8	0.8	5.75	0.5	7.1	0.7
0930	7.9	0.9	8.1	0.9	8.2	4.0	7.9	0.7	8.5	0.8	3.9	1.1	7.2	0.8
1000	8.15	0.8	8.3	0.8	8.45	4.7	7.7	0.5	7.95	0.9	3.1	1.5	7.4	0.6
1030	7.8	1.2	7.8	0.4	7.2	5.5	6.9	0.7	7.3	0.9	6.7	0.3	7.6	0.7
1100	7.1	1.3	8.2	0.6	6.9	2.6	7.25	0.7	8.35	1.4	6.25	0.5	7.4	0.6
1130	7.35	0.8	8.0	0.8	8.9	3.5	8.05	0.4	7.75	1.1	7.5	0.15	7.4	0.6
1200	7.75	1.5	7.75	0.5	7.5	1.8	7.0	1.1	7.25	1.2	7.6	0.2	7.3	0.6
1230	7.0	1.2	7.9	0.8	7.8	0.6	7.8	0.9	8.25	0.9	7.4	0.2	7.1	0.4
1300	7.6	0.5	7.45	0.5	7.75	0.8	7.15	0.8	7.9	0.9	7.6	0.2	7.2	0.4
1330	7.5	1.6	8.4	0.7	8.00	0.8	7.4	0.6	7.5	0.8	7.5	0.2	7.4	0.4
1400	7.7	1.3	8.1	0.6	7.8	1.3	8.0	0.7	8.6	0.9	7.4	0.7	7.2	0.5
1430	7.6	1.6	7.7	0.5	7.75	1.8	7.5	0.8	6.5	2.0	8.1	0.6	7.2	0.6
1500	6.65	2.1	8.45	1.1	6.8	1.8	7.8	1.3	7.15	2.3	7.55	0.8	7.2	1.1
1530	8.7	1.6	7.9	1.1	8.65	1.5	7.55	0.7	7.5	1.6	8.15	0.8	7.2	0.6
1600	7.9	1.7	8.7	1.2	8.75	2.1	8.4	0.7	7.4	2.1	7.6	0.9	7.3	0.6
1630	6.55	2.1	6.4	2.0	8.65	1.5	7.4	1.3	9.1	1.2	7.2	1.0	7.2	0.9
1700	10.4	2.6	7.4	1.4	7.85	1.4	7.3	1.0	7.25	1.9	7.15	1.3	7.3	0.9
1730	7.65	2.4	7.5	1.7	8.1	1.7	7.3	1.5	7.5	1.6	7.3	3.3	7.2	0.8
1800	7.67	1.5	7.4	1.4	8.2	1.9	7.3	0.9	7.3	1.6	7.1	0.9	7.2	1.0
1830	7.64	1.7	7.5	2.9	7.75	1.8	7.0	1.8	7.0	1.5	6.85	1.4	7.2	0.7
1900	7.0	1.5	7.3	0.9	7.5	1.5	7.05	1.6	7.25	1.5	7.1	1.1	7.35	0.8
1930	7.2	2.0	7.25	1.3	7.4	1.5	7.85	1.3	6.45	1.6	7.3	1.4	7.3	0.9
2000	6.1	1.6	9.0	0.5	7.35	0.5	8.6	1.7	6.3	1.4	7.25	1.4	7.3	1.0
2030	6.4	1.5	8.1	0.9	8.6	1.0	7.45	1.3	6.9	1.0	7.1	1.1	6.7	1.4
2100	7.25	1.3	7.4	1.4	7.6	1.5	7.9	1.5	7.2	1.2	7.15	1.7	7.05	0.6
2130	7.4	2.0	7.3	0.8	7.4	1.4	7.2	1.4	7.2	1.1	7.15	1.8	7.2	0.8
2200	7.0	1.9	7.2	1.1	6.8	1.4	7.2	1.3	7.2	1.0	7.1	1.9	7.2	0.8
2230	8.0	1.8	7.45	1.4	7.5	1.5	6.6	1.7	7.3	1.0	7.15	1.3	6.9	0.3
2300	7.4	1.9	7.1	1.2	7.3	1.0	6.5	1.5	6.6	1.9	7.0	1.4	7.1	0.5
2330	7.2	2.0	6.9	1.1	7.9	1.9	6.8	2.0	6.7	1.6	7.0	1.5	7.2	0.3
2400	7.25	1.8	6.65	1.0	7.4	1.3	7.4	1.5	7.1	1.4	6.9	1.7	7.1	0.6

SAN FRANCISCO PILOT PLANT STUDY
NORTH POINT INFLUENT – APRIL 1973

	MON.–16		TUE.–24		WED.–18		THU.–26		FRI.–20		SAT.–28		SUN.–22	
TIME	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO
0030	6.8	1.5	7.2	2.1	7.05	–	–	–	6.7	1.3	7.05	0.8	7.05	2.0
0100	6.7	–	7.25	2.3	7.05	1.2	–	–	6.95	1.2	7.1	0.7	7.1	2.3
0130	6.7	1.2	7.3	2.5	7.2	–	–	–	6.8	1.0	7.2	0.9	7.05	2.6
0200	7.1	–	7.3	2.5	7.1	0.9	–	–	7.0	1.0	7.0	0.9	6.95	2.4
0230	6.75	1.8	7.2	2.2	6.95	–	–	–	7.15	1.4	7.05	0.8	6.9	2.2
0300	6.2	–	7.25	2.3	7.1	0.8	–	–	6.65	1.4	6.0	3.6	6.6	2.3
0330	7.2	1.9	7.25	2.1	7.15	–	–	–	6.8	1.2	6.4	1.7	5.7	2.3
0400	6.9	–	7.3	2.9	6.8	1.2	–	–	7.1	1.5	6.95	0.9	6.7	2.7
0430	7.15	1.5	7.15	2.2	7.05	–	–	–	8.55	1.6	7.0	0.5	6.85	2.5
0500	7.2	–	7.35	2.6	7.2	1.5	–	–	7.2	1.6	7.1	0.8	7.1	2.6
0530	6.8	2.0	7.3	2.5	7.2	–	–	–	7.05	1.4	7.1	0.4	7.05	2.4
0600	7.3	–	7.3	3.2	7.1	1.8	–	–	6.9	1.6	7.1	0.8	6.95	2.5
0630	7.3	2.1	7.15	2.3	7.2	–	–	–	6.9	1.5	7.1	0.7	6.55	2.9
0700	7.4	–	7.25	2.4	7.15	2.0	–	–	6.9	1.5	7.1	0.5	6.8	2.6
0730	7.6	2.2	7.2	2.5	8.2	–	–	–	7.0	1.0	7.3	0.7	7.1	2.8
0800	7.6	–	7.4	2.3	7.4	1.2	7.6	1.4	7.4	2.1	7.4	0.4	7.1	2.3
0830	8.4	1.6	7.8	1.4	8.5	–	7.6	1.6	7.1	1.9	7.5	0.4	7.4	2.2
0900	8.1	–	7.7	1.1	7.4	0.9	7.6	1.2	7.3	1.9	7.7	0.2	7.3	2.3
0930	7.8	1.1	7.7	0.5	7.5	–	7.7	1.0	7.3	1.7	7.6	0.2	7.4	1.7
1000	7.8	–	7.8	0.8	7.8	0.6	7.7	1.2	7.4	1.6	7.5	0.3	7.8	3.6
1030	7.7	1.1	8.0	0.9	7.4	–	8.1	0.8	7.8	2.2	7.4	0.2	7.7	1.6
1100	7.8	–	7.8	0.9	7.9	0.7	9.5	1.7	7.4	2.3	7.5	0.3	7.5	1.6
1130	7.8	1.1	7.7	0.7	8.1	–	9.2	1.7	7.3	2.1	8.1	0.3	7.9	1.7
1200	9.2	–	7.7	0.8	7.8	0.6	7.8	0.8	7.4	2.0	8.0	0.3	7.4	1.8
1230	9.0	1.3	7.9	0.7	7.9	–	7.6	0.9	7.7	1.9	7.5	1.0	7.4	1.3
1300	8.1	–	7.4	0.8	7.4	0.6	8.2	0.9	7.5	1.9	9.6	0.5	7.3	1.3
1330	7.6	1.1	7.4	0.7	7.6	–	7.8	0.9	7.2	2.0	8.4	0.4	7.2	1.4
1400	8.2	–	7.7	1.6	7.7	0.6	7.7	0.8	7.3	1.8	7.5	0.3	7.2	1.3
1430	8.0	1.0	8.0	2.1	7.3	–	7.3	0.7	7.3	1.8	7.3	0.4	7.1	1.3
1500	7.6	–	7.6	2.0	7.4	0.8	7.5	0.8	7.1	1.8	7.4	0.4	7.1	1.0
1530	7.6	1.2	7.6	1.8	7.3	0.7	7.6	0.6	8.7	1.9	7.3	0.3	7.0	1.1
1600	7.5	–	7.6	2.2	7.1	–	7.3	0.9	8.6	1.9	9.2	1.0	6.9	1.1
1630	7.8	1.6	7.7	1.7	7.1	2.5	7.2	1.1	7.6	2.3	7.7	0.5	6.9	1.3
1700	7.3	–	7.5	1.4	7.5	2.8	7.4	1.2	7.3	2.0	7.6	0.7	7.0	1.4
1730	7.6	1.4	7.4	2.2	7.1	2.8	7.4	0.7	7.2	2.1	7.5	1.0	7.0	1.6
1800	7.6	–	7.7	2.8	7.6	2.8	7.5	1.0	7.5	2.1	7.5	0.7	7.1	1.5
1830	7.55	1.2	7.6	2.4	7.2	2.6	7.4	1.1	7.2	1.9	7.2	0.9	7.3	1.4
1900	7.5	–	7.3	2.6	7.0	2.7	7.7	1.2	7.1	1.9	7.2	0.6	7.0	1.4
1930	7.3	0.8	7.1	2.5	6.95	2.8	7.2	1.1	7.1	2.0	7.4	0.8	7.0	1.4
2000	7.1	–	7.2	2.1	7.1	2.6	7.0	1.1	7.1	1.9	7.2	0.3	7.1	1.4
2030	6.9	–	7.4	1.6	6.95	2.6	7.3	1.1	7.0	1.9	7.6	0.5	7.0	1.2
2100	6.8	–	7.3	1.8	7.5	2.7	8.0	1.1	7.0	2.0	7.4	0.8	7.0	1.2
2130	7.05	–	7.2	1.8	7.0	3.0	7.6	0.9	7.0	2.0	7.1	1.4	7.2	1.3
2200	6.7	1.1	7.2	1.9	7.0	3.0	7.2	0.9	7.1	1.8	7.0	0.9	7.2	1.4
2230	7.3	–	7.1	2.1	7.0	3.0	7.1	0.9	7.0	1.7	7.0	0.8	7.1	1.3
2300	7.1	1.7	7.2	2.2	6.9	2.8	7.1	0.9	7.0	1.8	7.1	0.9	7.2	1.3
2330	7.2	–	7.2	2.1	6.9	3.0	7.1	1.1	7.0	1.8	7.1	0.4	7.2	1.3
2400	6.9	–	–	–	7.0	2.7	7.3	0.9	7.0	1.7	7.1	0.8	7.2	1.4

SAN FRANCISCO PILOT PLANT STUDY
RICHMOND-SUNSET INFLUENT – APRIL 1973

	MON.–16		TUE.–24		WED.–18		THU.–26		FRI.–20		SAT.–28		SUN.–22	
TIME	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO	pH	DO
0030	–	–	7.5	1.0	7.15	1.4	7.5	1.0	7.05	1.6	6.8	2.0	6.8	1.8
0100	–	–	7.6	1.5	7.9	2.2	7.6	1.1	7.2	1.7	7.25	1.9	7.2	1.5
0130	–	–	7.6	1.8	8.4	2.2	7.5	1.1	7.4	1.9	7.2	2.2	7.3	1.8
0200	–	–	7.6	1.9	7.9	3.3	7.6	1.2	7.5	1.7	7.25	2.3	7.3	1.0
0230	–	–	7.2	1.8	6.9	4.1	7.4	1.5	7.0	2.1	7.0	2.5	6.9	0.9
0300	–	–	7.5	1.9	7.4	2.2	7.4	1.5	7.0	1.8	7.1	2.6	6.8	0.8
0330	–	–	7.3	2.9	7.4	4.2	7.1	2.3	7.1	2.6	7.2	2.5	6.25	1.5
0400	–	–	7.35	3.4	7.0	4.0	7.2	2.6	7.1	3.2	7.3	2.6	6.4	2.0
0430	–	–	7.15	3.1	7.2	4.0	7.2	3.2	6.9	3.7	7.0	3.2	6.4	2.2
0500	–	–	7.35	3.7	7.3	4.0	7.3	3.6	7.0	4.2	7.1	3.2	6.4	2.9
0530	–	–	7.45	4.5	7.35	4.0	7.3	3.5	7.1	4.0	7.25	4.1	6.7	3.5
0600	–	–	7.6	4.0	7.4	3.9	7.2	3.3	7.15	3.9	7.15	4.4	6.1	3.5
0630	–	–	7.7	2.7	7.6	3.7	7.7	2.5	7.0	2.9	7.2	3.8	6.5	3.4
0700	–	–	8.0	2.5	7.85	2.8	7.9	1.6	7.5	3.2	7.4	3.8	6.9	3.0
0730	–	–	8.15	2.0	8.15	2.5	8.0	1.0	7.6	2.6	7.75	3.4	7.0	2.6
0800	–	–	8.4	0.6	7.9	1.5	8.4	0.1	8.1	2.1	7.75	3.2	6.9	2.0
0830	–	–	8.5	0.5	7.5	1.5	8.3	0.2	8.2	1.0	8.5	1.0	8.05	0.2
0900	–	–	8.25	0.5	7.9	1.4	8.2	0.1	8.1	0.8	8.4	1.0	8.0	0.5
0930	–	–	8.15	0.6	7.9	1.4	8.1	0.2	7.9	0.8	8.25	1.1	7.8	0.3
1000	–	–	7.85	0.7	7.5	0.9	8.1	0.3	7.9	1.3	8.0	0.8	7.75	0.5
1030	–	–	7.8	0.9	7.7	1.5	7.7	0.3	7.7	1.4	8.1	0.8	7.6	0.2
1100	–	–	7.55	0.7	7.6	1.5	7.4	0.3	7.65	1.5	7.9	1.1	7.35	0.6
1130	–	–	7.55	0.9	7.5	1.2	7.5	0.3	7.4	1.8	7.85	1.5	7.3	0.7
1200	–	–	7.5	1.2	7.2	1.1	7.5	0.4	7.5	1.8	7.7	1.6	7.15	0.6
1230	–	–	7.6	0.9	6.8	1.3	7.4	0.3	7.5	1.5	7.55	1.7	7.1	0.6
1300	–	–	6.8	1.1	7.0	1.4	7.4	0.3	7.5	1.5	7.45	1.7	6.9	0.9
1330	–	–	7.3	1.3	7.4	1.4	7.4	0.4	7.4	1.4	7.4	1.9	6.85	0.9
1400	–	–	7.35	1.2	7.4	1.4	7.2	0.3	7.2	2.0	7.4	2.0	6.9	0.9
1430	–	–	7.35	1.3	7.3	1.65	7.4	0.4	7.15	1.9	7.4	1.8	7.05	0.6
1500	–	–	7.3	1.2	7.2	1.8	7.35	0.3	7.15	2.4	7.35	1.9	7.05	0.6
1530	–	–	7.35	0.9	7.3	1.8	7.4	0.3	7.15	1.7	7.5	1.8	6.9	0.8
1600	–	–	–	1.6	7.3	1.6	6.95	0.9	7.2	1.8	–	2.0	6.9	1.0
1630	–	–	7.45	1.6	7.1	1.8	7.45	1.1	7.45	1.3	7.6	1.9	6.9	1.0
1700	–	–	7.45	1.9	7.45	2.0	7.5	1.2	6.3	2.4	7.6	1.4	–	1.3
1730	6.15	2.3	7.2	1.3	7.5	1.9	7.5	1.2	6.8	2.5	7.4	1.8	–	1.1
1800	6.8	2.0	6.9	1.5	6.8	2.1	7.2	1.0	6.9	1.9	7.2	1.9	6.5	1.2
1830	–	–	6.95	0.9	7.5	2.1	6.9	1.0	7.2	2.1	7.4	2.1	6.3	1.1
1900	6.6	2.3	6.90	1.1	6.8	2.0	7.3	0.7	7.1	2.7	7.2	1.8	6.3	0.8
1930	6.5	2.1	6.75	0.8	7.0	2.0	7.1	0.8	6.8	2.5	6.9	1.9	6.4	0.9
2000	6.6	1.7	7.1	0.4	6.7	1.8	7.1	0.4	6.9	1.9	7.0	1.8	6.3	0.8
2030	6.4	1.8	6.8	0.8	7.1	1.9	7.0	0.8	7.2	2.1	6.8	1.9	6.4	1.1
2100	6.4	2.0	6.9	0.7	7.0	1.2	7.1	0.7	7.1	2.7	7.1	1.8	6.6	0.9
2130	6.5	1.8	6.7	0.4	7.0	1.8	7.0	0.3	6.9	3.2	6.9	1.5	6.7	1.0
2200	6.8	2.2	7.05	0.8	6.8	1.8	7.05	0.8	7.0	2.9	7.0	1.8	7.1	0.7
2230	6.6	1.9	7.1	0.9	7.1	2.0	7.0	0.6	6.6	3.3	6.95	1.7	6.8	0.7
2300	6.8	2.0	6.9	0.6	6.8	1.7	7.0	0.8	6.4	3.4	6.9	1.9	6.5	0.6
2330	6.8	1.9	6.95	0.8	6.7	1.8	7.15	0.6	6.5	2.6	6.75	1.5	7.1	0.8
2400	6.85	2.0	7.05	0.7	7.1	1.9	7.2	0.8	6.7	2.4	7.15	1.6	6.9	1.0

APPENDIX B

APPENDIX B

BENCH SCALE PROGRAM OUTLINE AND TEST DATA

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APPENDIX B
(Continued)

Figure

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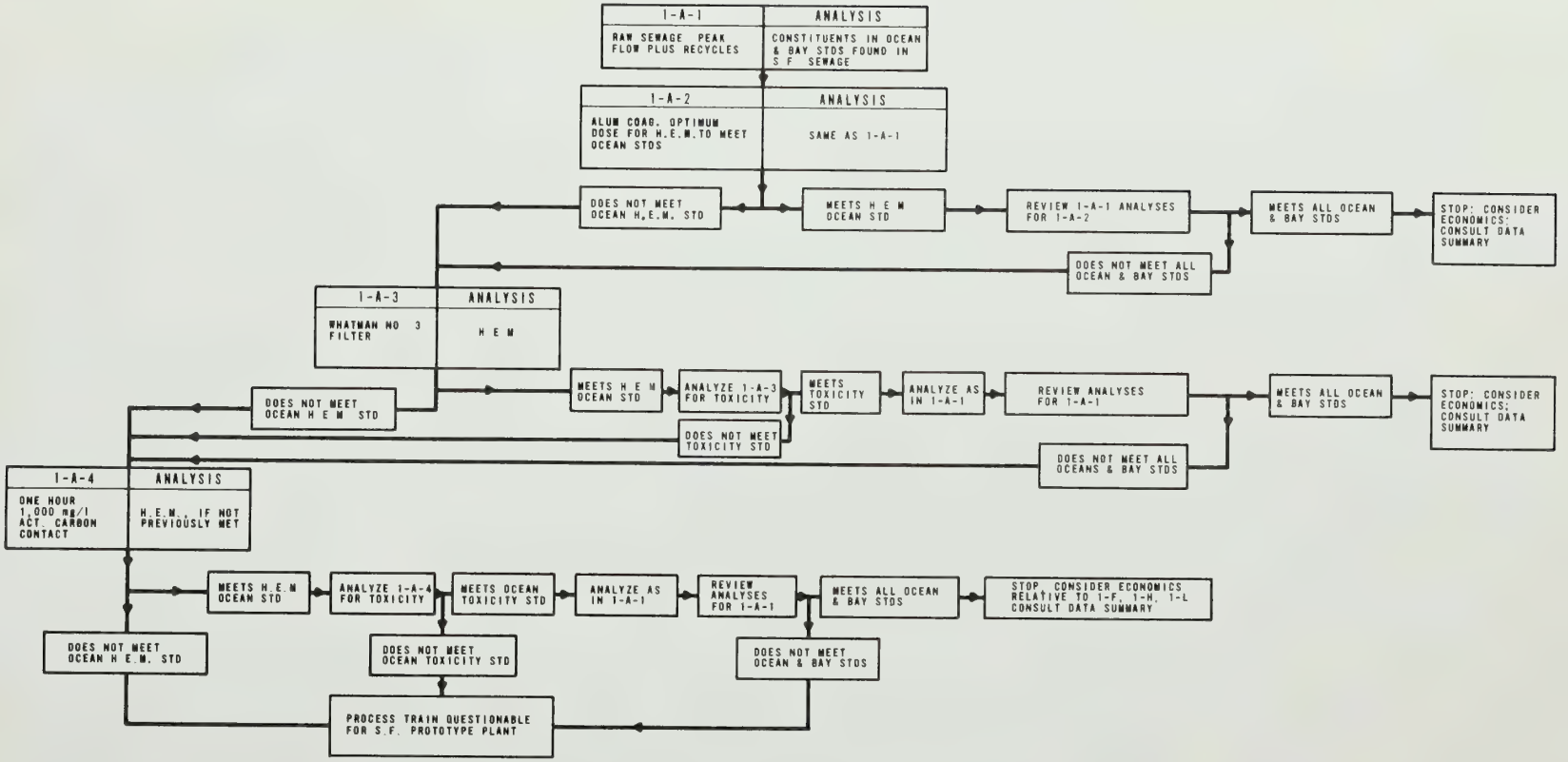
APPENDIX B
BENCH SCALE PROGRAM OUTLINE

PROGRAM 1.

Since the Ocean Discharge Standards are the most liberal, the minimum process which will meet those standards is the minimum process that would be constructed for a prototype San Francisco plant. Since the SWRCB does not require 85 percent BOD removal for an ocean discharge, we will ignore it initially for these studies, although it will be considered subsequently. Hexane Extractable Materials (HEM) is the next constituent which will be most difficult to remove in the proposed processes. Metals are expected to be either in concentrations that are below the standards in the raw sewage or the standards are so low it is doubtful that any of the processes will reduce the metals to the standards. Toxicity is a definite process problem, but it should only be examined after other standards have been met, since it reflects removals for all constituents.

In reference to the Program 1 Decision Tree, a peak flow raw sewage sample from all three plants will be collected to provide for simulation of the difficult coagulation conditions. The sample will be analyzed for all the constituents found in significant quantities in the raw sewage that are in the Ocean and Bay Standards, with the exception of toxicity. Jar tests will be run for a series of alum, ferric chloride, hi- (above pH 10.5) and lo-lime (below pH 10.5) dosages. The optimum dosage for clarity or solids removal will be analyzed for the above constituents in the


1-A-1
ANALYSIS
RAW SEWAGE PEAK FLOW PLUS RECYCLES
CONSTITUENTS IN OCEAN & BAY STDS FOUND IN S F SEWAGE
1-A-2
ANALYSIS
ALUM COAG. OPTIMUM DOSE FOR H.E.M. TO MEET OCEAN STDS
SAME AS 1-A-1
DOES NOT MEET OCEAN H.E.M. STD
MEETS H E M OCEAN STD
REVIEW 1-A-1 ANALYSES FOR 1-A-2
MEETS ALL OCEAN & BAY STDS
STOP: CONSIDER ECONOMICS: CONSULT DATA SUMMARY
DOES NOT MEET ALL OCEAN & BAY STDS
1-A-3
ANALYSIS
WHATMAN NO 3 FILTER
H E M
DOES NOT MEET OCEAN H E M STD
MEETS H E M OCEAN STD
ANALYZE 1-A-3 FOR TOXICITY
MEETS TOXICITY STD
ANALYZE AS IN 1-A-1
REVIEW ANALYSES FOR 1-A-1
MEETS ALL OCEAN & BAY STDS
STOP: CONSIDER ECONOMICS; CONSULT DATA SUMMARY
DOES NOT MEET TOXICITY STD
DOES NOT MEET ALL OCEANS & BAY STDS
1-A-4
ANALYSIS
ONE HOUR 1,000 mg/l ACT. CARBON CONTACT
H.E.M., IF NOT PREVIOUSLY MET
MEETS H.E.M OCEAN STD
ANALYZE 1-A-4 FOR TOXICITY
MEETS OCEAN TOXICITY STD
ANALYZE AS IN 1-A-1
REVIEW ANALYSES FOR 1-A-1
MEETS ALL OCEAN & BAY STDS
STOP. CONSIDER ECONOMICS RELATIVE TO 1-F, 1-H, 1-L CONSULT DATA SUMMARY
DOES NOT MEET OCEAN H.E.M. STD
DOES NOT MEET OCEAN TOXICITY STD
DOES NOT MEET OCEAN & BAY STDS
PROCESS TRAIN QUESTIONABLE FOR S.F. PROTOTYPE PLANT

NOTES:

1. A – ALUM
   F – FERRIC CHLORIDE
   H – HI-LIME
   L – LO-LIME
2. SUBSTITUTE EACH COAGULANT INTO PROCESS TRAIN (RECARBONATION REQUIRED FOR LIME PROCESSES)
3. LIME ADDITION MAY BE REQUIRED FOR ALUM AND FERRIC CHLORIDE COAGULATION ALKALINITY ADJUSTMENTS.
4. COMPARE ALL CONSTITUENTS OF CONCERN IN OCEAN AND BAY STDS FOR REMOVALS WITH EACH COAGULANT IN 1-A-2.

BENCH TEST PROGRAM I
FOR
SE, NP, AND RS
PHYSICAL/CHEMICAL
ALUM, FERRIC,
HI AND LO LIME

raw sewage plus toxicity. The removal of the so called "constituents of concern" can be compared for all three coagulants. This will be valuable information for later bench studies.

It is anticipated that HEM will be the key constituent for removal, therefore, it will be studied more extensively in this coagulation step. Also, HEM will be used to enter the decision tree process. If a coagulation effluent cannot meet the HEM Ocean Standard, then it will be filtered with a Buchner Funnel and Whatman No. 3 filter paper which simulates a filtration process. If the filter effluent does not meet the HEM Ocean Standard then it will be contacted for one hour with a 1,000 mg/l dose of carbon. If the carbon process cannot meet the standard then this physical/chemical process for a particular coagulant is questionable for use in the prototype plant.

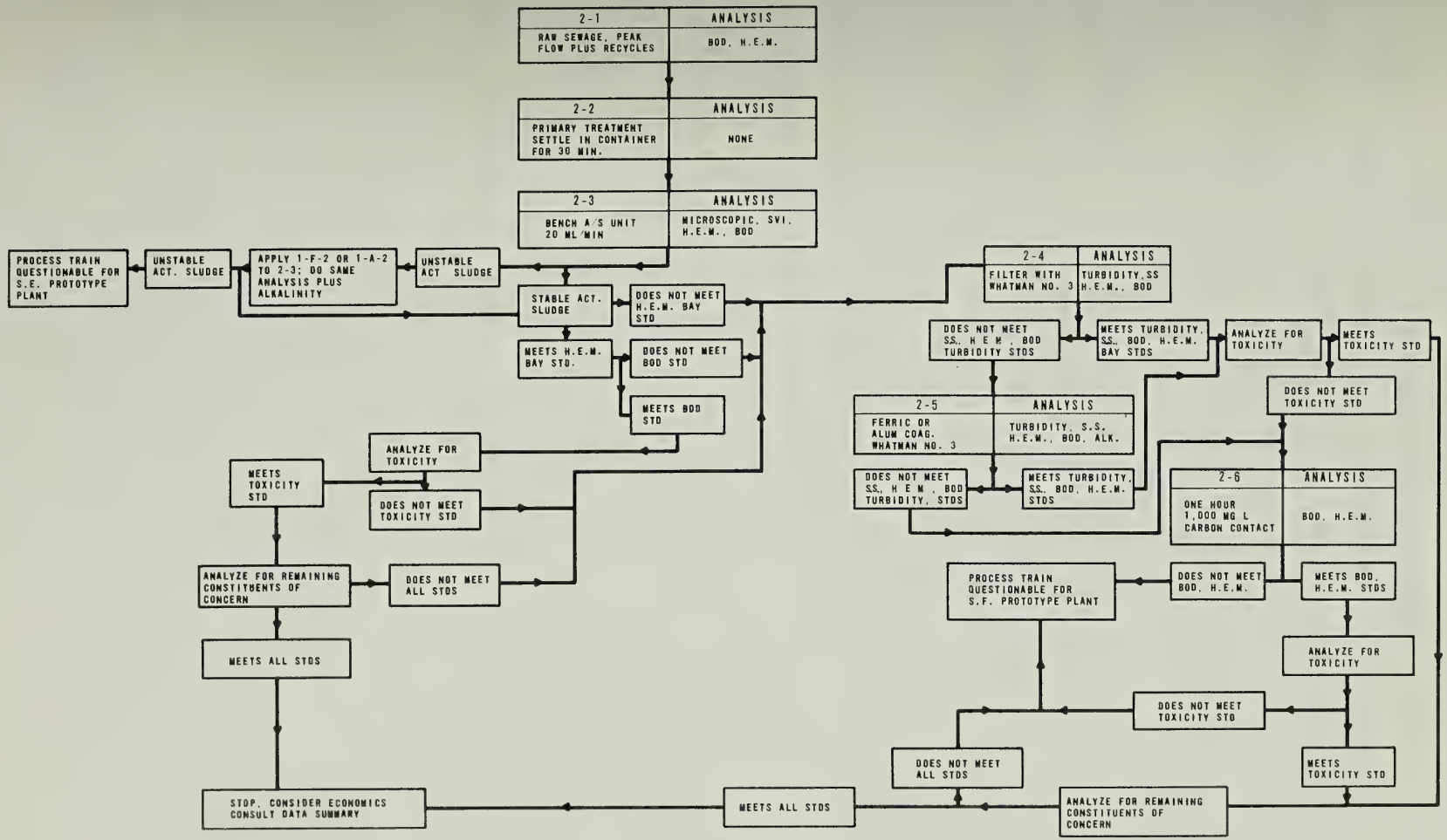
Realistically the HEM requirement may be met after filtration. If this is the case then the effluent would be analyzed for toxicity, which would likely be the next problem constituent. If the toxicity results are negative, then further treatment with carbon will be necessary. If the toxicity results meet the standards, then the entire laundry list of constituents in the raw sewage will be analyzed. If all standards are not met, then further treatment with carbon will be provided. If all standards are met, then the economics of different coagulant dosages will be considered. Also the results will be compared with similar processes across the country utilizing the data summary.

BENCH SCALE PROGRAM OUTLINE

PROGRAM 2.

In this program the stability of the activated sludge is the item of most concern in the biological-physical/ chemical process train. The generation of a stable activated sludge floc from the San Francisco sewage is a necessity before it can be a viable process for the City. Toxic constituents in the waste may retard the growth of desirable organisms resulting in the predominance of less desirable unstable organisms with corresponding reduced treatment efficiency. Secondary knowledge that may be gained is the removal of HEM, BOD, and toxicity in relation to the Bay or Ocean Standard. Also, the filterability of the biological floc and any coagulation requirements can be evaluated in relation to suspended solids standards.

In reference to Program 2 Decision Tree, peak flow raw sewage samples from Southeast and North Point will be evaluated individually in bench scale activated sludge units. The units will operate at a flow rate of 10 to 30 ml/min. Initially we will be examining the sludges stability with settleability and microscopic examinations. After a stable operating condition is achieved, we will analyze for BOD and HEM in the raw sewage and in the activated sludge effluent. If these constituent standards are met, toxicity will be checked in reference to the standards. If the toxicity evaluation is satisfactory, then the remaining constituents in the standards will be evaluated. If all constituents check out satisfactorily, the data can be consulted to ascertain how the San Francisco sewage compares with other municipalities across the country where data are available for the activated sludge process.


2-1
RAW SEWAGE, PEAK FLOW PLUS RECYCLES
ANALYSIS
BOD, H.E.M.
2-2
PRIMARY TREATMENT SETTLE IN CONTAINER FOR 30 MIN.
ANALYSIS
NONE
2-3
BENCH A/S UNIT 20 ML/MIN
ANALYSIS
MICROSCOPIC, SVI, H.E.M., BOD
PROCESS TRAIN QUESTIONABLE FOR S.E. PROTOTYPE PLANT
UNSTABLE ACT. SLUDGE
APPLY 1-F-2 OR 1-A-2 TO 2-3; DO SAME ANALYSIS PLUS ALKALINITY
UNSTABLE ACT SLUDGE
STABLE ACT. SLUDGE
DOES NOT MEET H.E.M. BAY STD
MEETS H.E.M. BAY STD.
DOES NOT MEET BOD STD
MEETS BOD STD
2-4
FILTER WITH WHATMAN NO. 3
ANALYSIS
TURBIDITY, SS H.E.M., BOD
DOES NOT MEET S.S., H E M , BOD TURBIDITY STDS
MEETS TURBIDITY, S.S., BOD, H.E.M. BAY STDS
ANALYZE FOR TOXICITY
MEETS TOXICITY STD
DOES NOT MEET TOXICITY STD
2-5
FERRIC OR ALUM COAG. WHATMAN NO. 3
ANALYSIS
TURBIDITY, S.S., H.E.M., BOD, ALK.
DOES NOT MEET S.S., H E M , BOD TURBIDITY, STDS
MEETS TURBIDITY, S.S., BOD, H.E.M. STDS
2-6
ONE HOUR 1,000 MG L CARBON CONTACT
ANALYSIS
BOD, H.E.M.
ANALYZE FOR TOXICITY
MEETS TOXICITY STD
DOES NOT MEET TOXICITY STD
MEETS TOXICITY STD
DOES NOT MEET TOXICITY STD
ANALYZE FOR REMAINING CONSTITBENTS OF CONCERN
DOES NOT MEET ALL STDS
MEETS ALL STDS
PROCESS TRAIN QUESTIONABLE FOR S.F. PROTOTYPE PLANT
DOES NOT MEET BOD, H.E.M.
MEETS BOD, H.E.M. STDS
ANALYZE FOR TOXICITY
DOES NOT MEET TOXICITY STD
MEETS TOXICITY STD
DOES NOT MEET ALL STDS
ANALYZE FOR REMAINING CONSTITUENTS OF CONCERN
MEETS ALL STDS
STOP, CONSIDER ECONOMICS CONSULT DATA SUMMARY

BENCH TEST PROGRAM 2
FOR
SE AND NP BIOLOGICAL,
PHYSICAL/CHEMICAL

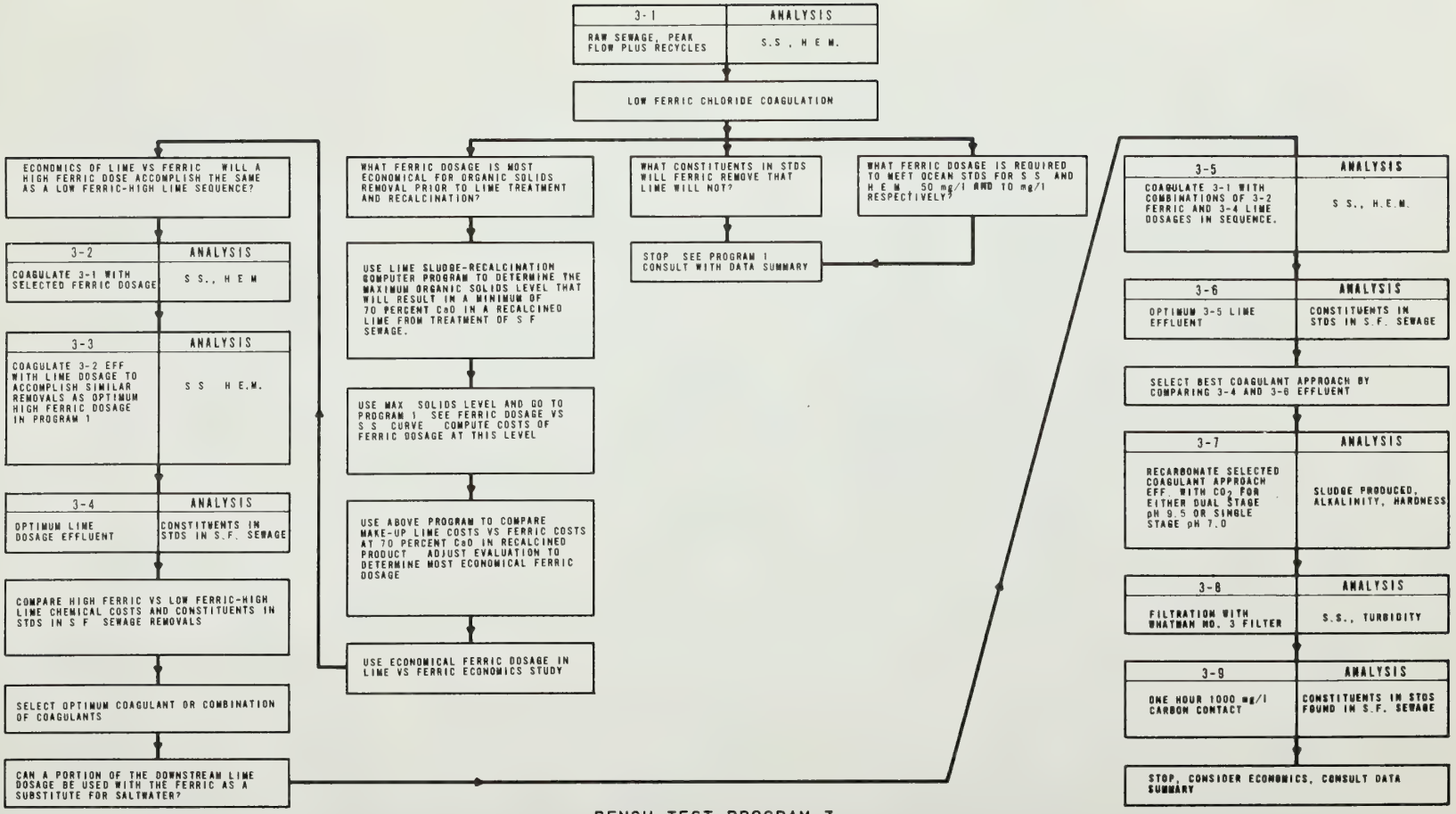
However, it is anticipated that filtration will be required after the activated sludge process to meet the HEM and suspended solids requirements. If problems are encountered in filtration because of a colloidal activated sludge floc or filter solids loadings are excessive, then alum or ferric chloride coagulation and clarification will be simulated to prepare the waste for filtration. If BOD, HEM, SS and turbidity requirements are met, then toxicity tests will be run for standards comparison to see if activated carbon treatment is necessary. As the decision tree indicates, depending on when toxicity falls out, the remaining constituents of concern will be evaluated for comparison with the standards to identify if this process train is viable for San Francisco.

BENCH SCALE PROGRAM OUTLINE

PROGRAM 3.

In Program 3 we will be investigating the low ferric-lime-physical/chemical process. Since the primary purpose of the low ferric coagulation is to remove organic solids to enhance the lime treatment and recalcination processes, the first item of concern is to identify the low ferric dosage most economical for solids removal and chemical costs. First we will use a lime sludge recalcination computer program to determine the maximum organic solids level in the low ferric effluent that will achieve a 70 percent CaO value in the recalcined lime from lime treatment of San Francisco sewage. After determination of the solids level, Program 1 will be consulted to determine what ferric dosage will accomplish the desired solids level. Then the ferric costs versus the make-up lime dosage costs will be compared and the most economical procedure determined. Also Program 1 can be consulted to identify which constituents will be removed more efficiently for ferric over lime and vice versa. In reference to the Ocean Discharge Standards program, the approximate low ferric dosage to achieve 50 mg/l SS and 10 mg/l HEM can be derived from Program 1 and utilized in Program 2 considerations.

After the optimum ferric dosage is determined from above, it would be beneficial to compare the usage of a high ferric dosage from Program 1 in lieu of a low ferric - lo- or hi-lime dosage. The low ferric effluent will be coagulated with lo- and hi-lime dosages to produce an effluent comparable to the high ferric dosage. The economics of the two dosages can be compared for chemical costs, sludge handling, etc.


3-1
ANALYSIS
RAW SEWAGE, PEAK FLOW PLUS RECYCLES
S.S., H.E.M.
LOW FERRIC CHLORIDE COAGULATION
ECONOMICS OF LIME VS FERRIC WILL A HIGH FERRIC DOSE ACCOMPLISH THE SAME AS A LOW FERRIC-HIGH LIME SEQUENCE?
WHAT FERRIC DOSAGE IS MOST ECONOMICAL FOR ORGANIC SOLIDS REMOVAL PRIOR TO LIME TREATMENT AND RECALCINATION?
WHAT CONSTITUENTS IN STDS WILL FERRIC REMOVE THAT LIME WILL NOT?
WHAT FERRIC DOSAGE IS REQUIRED TO MEET OCEAN STDS FOR S.S. AND H.E.M., 50 mg/l AND 10 mg/l RESPECTIVELY?
3-2
ANALYSIS
COAGULATE 3-1 WITH SELECTED FERRIC DOSAGE
S.S., H.E.M.
USE LIME SLUDGE-RECALCINATION COMPUTER PROGRAM TO DETERMINE THE MAXIMUM ORGANIC SOLIDS LEVEL THAT WILL RESULT IN A MINIMUM OF 70 PERCENT CaO IN A RECALCINED LIME FROM TREATMENT OF S.F. SEWAGE.
STOP SEE PROGRAM 1 CONSULT WITH DATA SUMMARY
3-3
ANALYSIS
COAGULATE 3-2 EFF WITH LIME DOSAGE TO ACCOMPLISH SIMILAR REMOVALS AS OPTIMUM HIGH FERRIC DOSAGE IN PROGRAM 1
S.S. H.E.M.
USE MAX. SOLIDS LEVEL AND GO TO PROGRAM 1 SEE FERRIC DOSAGE VS S.S. CURVE COMPUTE COSTS OF FERRIC DOSAGE AT THIS LEVEL
3-4
ANALYSIS
OPTIMUM LIME DOSAGE EFFLUENT
CONSTITUENTS IN STDS IN S.F. SEWAGE
USE ABOVE PROGRAM TO COMPARE MAKE-UP LIME COSTS VS FERRIC COSTS AT 70 PERCENT CaO IN RECALCINED PRODUCT ADJUST EVALUATION TO DETERMINE MOST ECONOMICAL FERRIC DOSAGE
COMPARE HIGH FERRIC VS LOW FERRIC-HIGH LIME CHEMICAL COSTS AND CONSTITUENTS IN STDS IN S.F. SEWAGE REMOVALS
USE ECONOMICAL FERRIC DOSAGE IN LIME VS FERRIC ECONOMICS STUDY
SELECT OPTIMUM COAGULANT OR COMBINATION OF COAGULANTS
CAN A PORTION OF THE DOWNSTREAM LIME DOSAGE BE USED WITH THE FERRIC AS A SUBSTITUTE FOR SALTWATER?
3-5
ANALYSIS
COAGULATE 3-1 WITH COMBINATIONS OF 3-2 FERRIC AND 3-4 LIME DOSAGES IN SEQUENCE.
S.S., H.E.M.
3-6
ANALYSIS
OPTIMUM 3-5 LIME EFFLUENT
CONSTITUENTS IN STDS IN S.F. SEWAGE
SELECT BEST COAGULANT APPROACH BY COMPARING 3-4 AND 3-6 EFFLUENT
3-7
ANALYSIS
RECARBONATE SELECTED COAGULANT APPROACH EFF. WITH CO_2 FOR EITHER DUAL STAGE pH 9.5 OR SINGLE STAGE pH 7.0
SLUDGE PRODUCED, ALKALINITY, HARDNESS
3-8
ANALYSIS
FILTRATION WITH WHATMAN NO. 3 FILTER
S.S., TURBIDITY
3-9
ANALYSIS
ONE HOUR 1000 mg/l CARBON CONTACT
CONSTITUENTS IN STDS FOUND IN S.F. SEWAGE
STOP, CONSIDER ECONOMICS, CONSULT DATA SUMMARY

BENCH TEST PROGRAM 3
FOR
SE, NP, AND RS
$FeCl_3$+LIME

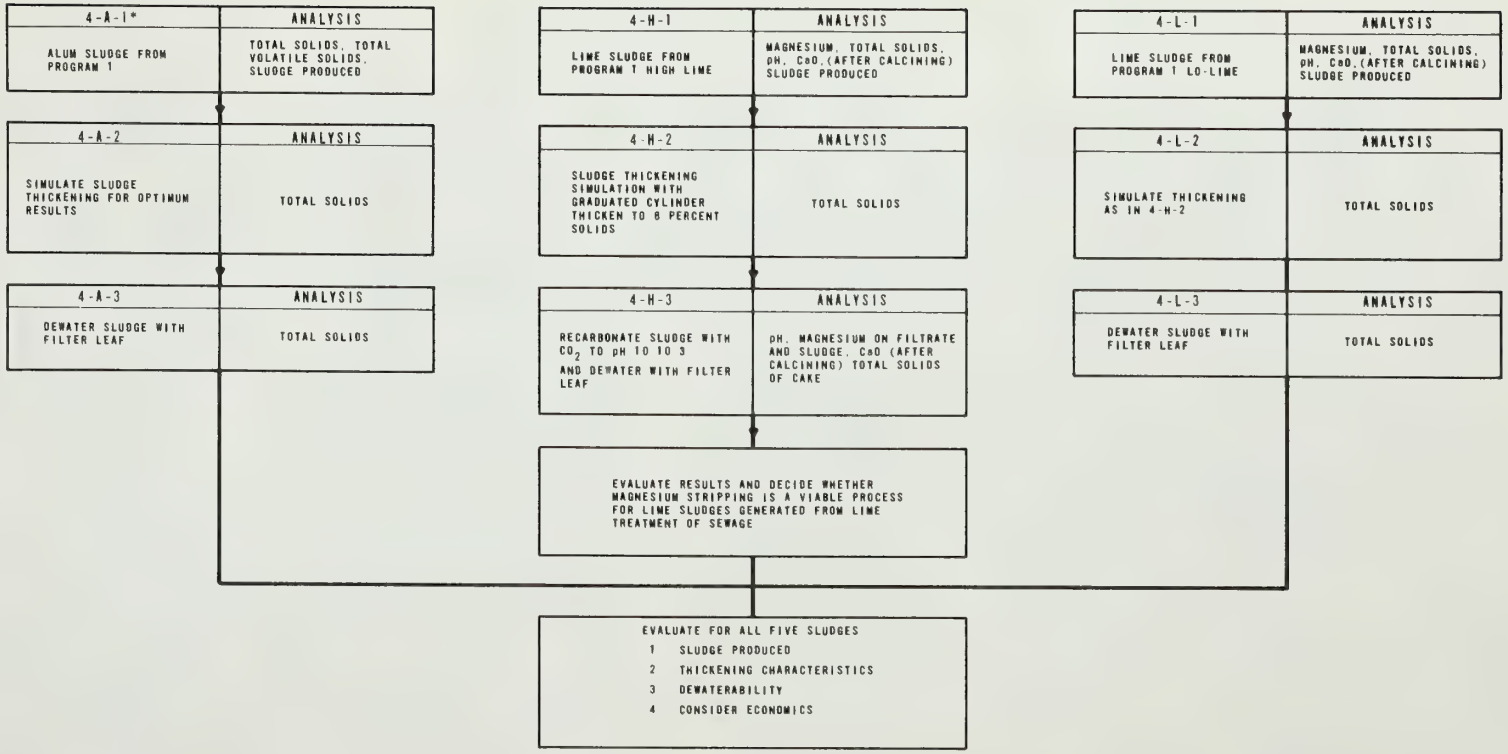
If the low ferric - hi- or lo-lime system is the most economical, a study will be conducted to determine if a portion of the lime dosage can be used with the ferric dosage as a substitute for saltwater. Most of the above studies will be evaluated using SS and HEM analyses, however, for final determination of the best coagulation procedure, all constituents of concern will be evaluated. Further treatment with recarbonation, filtration, and carbon will be simulated to determine if all standards can be met with this process train, particularly 85 percent BOD removal.

PROGRAM 4.

In Program 4 the five types of possible sludge resulting from the coagulation and biological processes can be evaluated for the amount of sludge produced, thickening characteristics, dewaterability, and the resulting economics.

Of particular concern is the magnesium problem in relation to lime sludge recalcination economics. If physical corrections to prevent saltwater infiltration are not satisfactory in the San Francisco collection system, then a means of magnesium removal from the lime sludge must be accomplished or it is unlikely lime will be viable treatment process for the City.

Two approaches will be attempted to reduce the high concentrations of magnesium in the lime sludge. The first method would be to operate the lime coagulation process at pH 11.0 plus and then recarbonate the resulting sludge to pH 9.5 - 10.0 to redissolve the magnesium hydroxide, but retain



*SUBSTITUTE F AND B IN THIS STUDY ALSO

A - ALUM
F - FERRIC CHLORIDE
H - HI-LIME
L - LO-LIME
B - BIOLOGICAL

BENCH TEST PROGRAM 4
SOLIDS HANDLING EVALUATION
FOR
SE, NP, AND RS
PHYSICAL/CHEMICAL

the calcium carbonate sludge. The dissolved magnesium would be separated from the calcium sludge with a lab centrifuge. The second possible method would be to operate the lime process below the theoretically precipitation point for magnesium hydroxide, below 10.8, probably below 10.5, and then determine the magnesium concentration in the resulting sludge. Of course, at this lower pH the removal of organic solids, metals, and HEM may be retarded, so the two methods must be considered from an overall viewpoint.

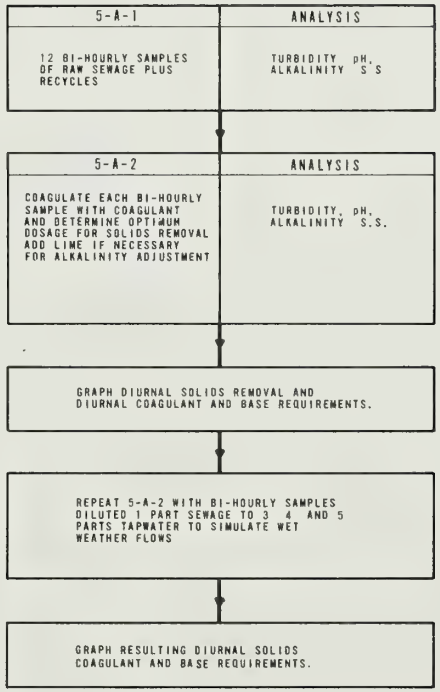
PROGRAM 5.

In Program 5 we will be looking at the diurnal coagulant requirements for alum, ferric chloride, and lime under wet and dry weather conditions. This will be used primarily for pilot plant operation.

COAGULATION TEST PROCEDURE

Stock solution of one percent standard alum, ferric chloride, and $Ca(OH)_2$ were prepared so that 1 milliter of a coagulant added to 1 liter of sewage resulted in a dosage of 10 mg/l. The polyelectrolyte solution of 0.05 percent was prepared so that 1 milliter added to 1 liter of sewage resulted in a dosage of 0.5 mg/l.

The standard alum solution was approximately 9 percent aluminum and the lime used was in excess of 90 percent CaO. The ferric chloride was obtained from the Southeast plant storage at approximately 42 to 44 percent ferric chloride. Polyelectrolytes used were Calgon WT-3000, and Nalco 676.


5-A-1
ANALYSIS
12 BI-HOURLY SAMPLES OF RAW SEWAGE PLUS RECYCLES
TURBIDITY, pH, ALKALINITY, S.S.
5-A-2
ANALYSIS
COAGULATE EACH BI-HOURLY SAMPLE WITH COAGULANT AND DETERMINE OPTIMUM DOSAGE FOR SOLIDS REMOVAL ADD LIME IF NECESSARY FOR ALKALINITY ADJUSTMENT
TURBIDITY, pH, ALKALINITY, S.S.
GRAPH DIURNAL SOLIDS REMOVAL AND DIURNAL COAGULANT AND BASE REQUIREMENTS.
REPEAT 5-A-2 WITH BI-HOURLY SAMPLES DILUTED 1 PART SEWAGE TO 3, 4, AND 5 PARTS TAPWATER TO SIMULATE WET WEATHER FLOWS
GRAPH RESULTING DIURNAL SOLIDS COAGULANT AND BASE REQUIREMENTS.

A - ALUM
F - FERRIC
H - LIME (HI)
L - LIME (LO)

SUBSTITUE ALL FOUR COAGULANTS IN STUDY

BENCH TEST PROGRAM 5
DIURNAL COAGULANT VARIATIONS
FOR
SE, NP, AND RS

BENCH SCALE PROGRAM OUTLINE

The sampling point for the preliminary Richmond-Sunset wastewater treatment plant study was at the exit of the grit removal facilities. The grab sample was transported to the CH2M HILL Mobile Laboratory at the Southeast plant, where the time of sampling and pH were recorded.

One liter aliquots were poured into beakers and placed on six-place gang stirrers. Rapid mixing was simulated at 100 rpm for 2 minutes. During this period the base (lime) was added initially followed by the coagulant either $FeCl_3$, or alum, and the polyelectrolyte was added in the middle of the period. The sample was then flocculated by 35 rpm for 5 minutes, then dynamically settled at 5 rpm for 30 minutes. At the end of the 30-minute period the supernatant was decanted into a container and analyzed for turbidity and pH. Some optimum dosages were analyzed for suspended solids and sludge volume produced. After the optimum dosages were selected, the runs were repeated to produce enough supernatant for commerical laboratory analysis.

DISCUSSION OF RESULTS

The significant data collected during the bench scale testing are shown in Tables B-1 thru B-13. Tables B-1 thru B-9 refer to a day's physical/chemical tests. Four of the extensive testing days were produced using the Southeast plant raw sewage, with and without the addition of saltwater or plant solids recycles. Two days were produced using North Point raw sewage without saltwater addition, and one day using Richmond-Sunset raw sewage with the normal solids handling recycles inherent in that plant. An

additional test consisted of a combination of three parts North Point raw sewage and one part Southeast raw sewage, with solids handling recycles added to the mixture but without the saltwater addition. Also one day was run with three parts Northpoint and one part each of Southeast and Richmond-Sunset without the saltwater addition. Other tables included in Appendix B will be referred to later in this section.

In reference to Bench Test Program 1, all optimum coagulant dosages of alum, ferric chloride, hi- and lo-lime meet the 10 mg/l HEM (oil and grease) requirement for ocean discharge, regardless of the raw sewage or combinations. Proceeding through the decision tree for each plant's raw sewage, we find the following indications of treatability. At Richmond-Sunset (Table B-1) in consideration of the Ocean policy only, all of the "laundry list," or constituents of concern in the raw sewage, are satisfactorily removed except BOD, which requires filtration and carbon treatment for all of the optimum coagulant dosages. Toxicity and floatables are not included in these analyses because of the difficulty in producing enough effluent for the former or a realiable sample for the latter in terms of sample and effluent handling.

At North Point (Tables B-2 and B-3), BOD, phenol, total chromium, TSS, and turbidity show indications of problems for meeting the more stringent tentative Bay standards for any coagulants used. TSS and turbidity are satisfactory for the Ocean requirements. After filtration and carbon, only BOD and total chromium indicate problems regardless of the coagulant used, in reference to Bay and Ocean Requirements.

At Southeast (Tables B-4 thru B-7) phenol, BOD, and total chromium are problem areas for all four coagulants in regard to Ocean requirements. Turbidity and TSS do not meet the Bay requirements, but they and phenol are no longer a problem after filtration. BOD and total chromium again do not meet either Bay or Ocean requirements regardless of the coagulant used.

For the run with North Point and Southeast raw sewages mixed (Table B-8), those constituents in violation of the Ocean requirements after coagulation are total chromium and BOD. In addition, turbidity, TSS and oil and grease would be in violation of the Bay requirements. After filtration and carbon treatment, only total chromium and BOD would be in violation of both requirements.

The results of test with the combination of raw sewages from all three plants (Table B-9) are essentially the same as from the tests of sewages from individual plants with only total chromium and BOD indicated to be problem constituents.

The results of the bench scale activated sludge operation are shown in Table B-10. Initially two units were operated on Southeast primary effluent with one unit receiving plant solids handling recycles equivalent to an 80 mgd (302,800 cu m/day) flow, and the other unit a 20-mgd (75,700 cu m/day) flow. This simulated the Southeast flow with its equivalent amount of recycles from North Point's contribution. Return sludge flow in the bench units was accomplished by adjusting the aeration "roll" in the aeration basin so that solids were pulled through a long slot into the basin. Difficulty in

TABLE B-1

PLANT:	R-S	**DATE:**	6-13-73	**TIME:** 0800	**pH:** 8.2	**ALK:**	
$FeCl_3$	175	**ALUM**	200	**LO-LIME**	200	**HI-LIME**	300
LIME	40		40		–		–
POLYMER	1		1		1		1

CONDITIONS: Influent to plant as on normal day.

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**
Final pH		7.5				7.5				10.3				11.2		
Turbidity, FTU						5.9				12				7.2		
SS		10				5.0				15.5				5.5		
Sludge Yield		242				302				279				466		
HEM		1.8	2.5	2		7.9	1.8	1.9		3.7	3.5	1.6		3.5	3.5	1.2
BOD		67		16		47		15		71		18		57		18
Phenol		.11	.098	.004		.11	.094	.004		.14	.094	.004		.13	.10	.004
Cd		<.001				<.001				<.001				<.001		
Cr		.003				.004				.003				.003		
Cu		.022				.020				.042				.028		
Cn		.005				.007				.01				.01		
Pb		.01				.01				.01				.01		
Mg		10.				9.4				9.2				6.6		
Hg		<.001		<.001		<.001		<.001		<.001		<.001		<.001		<.001
Ni		.026				.052				.017				.024		
Ag		.006				.006				.008				.008		
Zn		.053				.27				.075				.082		
COD				34				32				26				28

TABLE B-2

PLANT:	NP	**DATE:**	6-11-73	**TIME:**	0800	**pH:**	7.8	**ALK:**
$FeCl_3$	125	**ALUM**	150	**LO-LIME**	160			**HI-LIME** 360
LIME	60		20		–			–
POLYMER	1		1		1			1

CONDITIONS: No seawater; no recycles

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**
Final pH		7.2				7.3				10.4				11.4		
Turbidity, FTU		6				3.7				16				11		
SS		6				11.5				8.5				2.5		
Sludge Yield		214				251				329				466		
HEM	19	1.4	<.5	1.2		2.6	.6	.5		1.2	<.5	7.8		.9	<.5	1.3
BOD	94	30		20		41		31		48		26		55		26
Phenol	.04	.06	.05	<.01		.06	.07	<.01		.06	.10	<.01		.22	.07	<.01
Cd	.002	<.001				<.001				<.001				<.001		
Cr	.02	.006		.004		.005		.003		.004				.003		
Cu	.20	.02				.01				.03				.01		
Cn	.04	.02				.04				.04				.04		
Pb	.09	.008				.005				.01				.01		
Mg	25	26				15				20				3		
Hg	.001	.001		<.001		.001		<.001		.001		<.001		.001		<.001
Ni	.01	.008				.01				.008				.008		
Ag	.03	.004				.003				.005				.003		
Zn	1.9	.03				.06				.04				.03		
COD				<5				<5				<5				8

TABLE B-3

PLANT: NP DATE: 7-2-73 TIME: 1000 pH: 2 ALK:

	ALUM	$FeCl_3$	LO-LIME	HI-LIME
$FeCl_3$	175			
ALUM	200			
LO-LIME	250			
HI-LIME	450			
LIME	90	70	–	–
POLYMER	0.5	0.5	0.5	0.5

CONDITIONS: No seawater; no recycles

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C
Final pH		8.1				7.8				10.3				11		
Turbidity, FTU		20				12				17				18		
SS		42.5				30				40.5				28		
Sludge Yield		174				252				316				419		
HEM	34.2	9	2.4			3.2	1.6			5.3	2.5			10.4	2.5	
BOD	151	66		34		60		33		72		37		73		36
Phenol	1.28	1.69	1.66			1.67	1.78			1.32	1.41			1.49	1.49	
Cd																
Cr	.48	.44				.38				.56				.32		
Cu																
Cn																
Pb																
Mg	17	16				16				15				12		
Hg																
Ni																
Ag																
Zn																
COD	233	144		58		121		53		149		65		157		66

TABLE B-4

PLANT: SE **DATE:** 5-17-73 **TIME:** 0830 **pH:** 7.0 **ALK:**

$FeCl_3$	100	ALUM	125	LO-LIME	300	HI-LIME	570
LIME	50		40		–		–
POLYMER	0.5		0.5		0		0

CONDITIONS: Seawater on; no recyles

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C
Final pH		7.4				7.2				10.4				11.2		
Turbidity FTU		8.7				7.6				8.2				4.2		
SS		18.5				19.5										
Sludge Yield		580.7				271.9				693.4				1077		
HEM																
BOD	195	52		68		75		50		86		78		45		55
Phenol	1.2	1.1				1.2				1.1				1.1		
Cd	.003	.001				.001				< .001				< .001		
Cr	3.8	.31				.06				.05				.03		
Cu	.10	.007				.007				.003				.003		
Cn																
Pb	.08	< .01				< .01				< .01				< .01		
Mg																
Hg																
Ni	.087	.073				.056				.11				.046		
Ag	.017	.002				< .001				.001				.001		
Zn	.50	.05				.06				.02				.02		
COD	880	300				180				260				310		
Al	1.3	1.3				.05				.06				.01		
As	< .005	< .005				< .005				<.005				<.005		
Se	.08	.03				.02				.01				.01		
Be	< .001	< .001				< .001				<.001				<.001		
B	.69	.66				.66				.52				.42		
Color	180	46				60				34				33		
F	1.5	1.4				1				.66				.86		
Mn	.20	.12				.26				.004				.001		
Mo	< .002	< .002				< .002				< .002				< .002		
Floatables	5.2	1.3				1.8				2.3				6.3		
MBAS	.72	.40				.58				.71				.71		
SS	107	22				17				27				19		
Turbidity	160	14				15				30				11		

TABLE B-5

PLANT: SE **DATE:** 6-6-73 **TIME:** 0830 **pH:** 7.1 **ALK:**

$FeCl_3$	125	ALUM	125	LO-LIME	330	HI-LIME	570
LIME	60		40		–		–
POLYMER	1		1		0.5		0.5

CONDITIONS: Seawater off; recycles added

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C
Final pH		7.45				7.4				10.2				11		
Turbidity, FTU		7				5.5				13				8.4		
SS		18				4				24.5				19		
Sludge Yield		486.6				323				799.3						
HEM		5.1	5.2	<.1		1.4	2.3	.3		3.2	.75	.2		2.2	.3	.3
BOD		100		66		100		62		120		68		110		67
Phenol		6.1	.84	<.01		1	.94	<.01		1.8	.81	<.01		1	.74	<.01
Cd		.001				<.001				<.001				<.001		
Cr		.60		.19		.52		.11		.12		.02		.06		.009
Cu		.006				.007				.007				.003		
Cn		.03				.03				.03				.02		
Pb		.02				.01				.01				.01		
Mg		120				130				86				10		
Hg		<.001		<.001		<.001		<.001		<.001		<.001		<.001		<.001
Ni		.04				.06				.03				.02		
Ag		<.001				<.001				<.001				<.001		
Zn		.034				.045				.051				.022		
COD				92				92				108				110

TABLE B-6

PLANT:	SE	**DATE:**	6-21-73	**TIME:**	1000	**pH:** 7.7	**ALK:**	
$FeCl_3$	225	**ALUM**	250	**LO-LIME**	200		**HI-LIME**	300
LIME	80		60		–			–
POLYMER	0.5		0.5		0.5			0.5

CONDITIONS: No seawater; no recycle

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C
Final pH		7.5				7				10.3				11.3		
Turbidity, FTU		12				18				44				18		
SS		44				45.5				63				28		
Sludge Yield		595.9				602.4				586.9				812.3		
HEM	178	5.3	1.4	.9		7.6	2.8	.8		10.1	8.2	2		5.7	1.5	1.3
BOD	499	153		82		141		74		205		111		165		96
Phenol	.63	.54	.32	.01		.46	.51	.01		.62	.23	.01		.54	.32	.01
Cd	.019	.005				< .001				< .001				.012		
Cr	3.6	.13		.052		.025		.028		.15		.07		.065		.042
Cu	.215	.02				.013				.019				.012		
Cn	.015	.013				.013				.015				.01		
Pb	.11	.022				.023				.024				.019		
Mg	24	19				21				18				6.9		
Hg	.002	.0012		.0016				.0014				.0015				.0013
Ni	.084	.028				.053				.035				.028		
Ag	.05	.005				.003				.005				.004		
Zn	.66	.092				.085				.13				.061		
COD	1128			163				158				185				150

TABLE B-7

PLANT:	SE			**DATE:**	6-28-73			**TIME:** 1030		**pH:**	7.8	**ALK:**
$FeCl_3$	200			**ALUM**	225			**LO-LIME**	225			**HI-LIME** 550
LIME	80				50				–			–
POLYMER	.5				.5				.5			.5

CONDITIONS: No recycle; seawater on

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**
Final pH		7.3				6.9				10.8				10.9		
Turbidity, FTU		5				8.5				8.2				2.5		
SS		41				37				6				0		
Sludge Yield		278				322				229				874		
HEM	62.5	2.1	1.5			2.2	1.6			5.3	1.4			6	2	
BOD	217	70		44		64		46		84	46			70	43	
Phenol	.33	.22	.24			.3	.3			.28	.29			.25	.23	
Cd																
Cr	3.2	.38				.72				.6				.34		
Cu																
Cn																
Pb																
Mg	150	140				140				140				52		
Hg																
Ni																
Ag																
Zn																
COD	588	164		99		165		102		205		104		165	102	

TABLE B-8

PLANT: SE, NP **DATE:** 6-18-73 **TIME:** 1000 **pH:** 7.4 **ALK:**

$FeCl_3$	150	ALUM	175	LO-LIME	225	HI-LIME	425
LIME	70		30		–		–
POLYMER	1		1		1		1

CONDITIONS: No seawater; recycles added

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C	RAW	C&C	F	C
Final pH		7.3				7.3				10				11.3		
Turbidity, FTU		17				10				18				8.5		
SS		38				28.5				28.5				11.5		
Sludge Yield		338				344				502				811		
HEM	100	8	.8	1.1		6	.5	1.1		8	4.5	1.1		3	1.7	1.2
BOD	205	80		51		79		56		101		60		85		47
Phenol	.24	.18	.12	< .01		.16	.13	.02		.18	.14	< .01		.19	.16	< .01
Cd	.077	< .002				< .002				< .002				< .002		
Cr	.68	.03		< .01		.03		< .01		.07		< .01		< .01		< .01
Cu	.43	.02				< .02				.02				< .02		
Cn	.04	.03				.04				.05				.04		
Pb	.27	.01				< .01				.02				.01		
Mg	32	31				31				31				13		
Hg	.0021	.0019		.0016		.0017		.0014		.0015		.0012		.0014		.0015
Ni	.12	.05				.04				.04				.02		
Ag	.68	.008				< .005				.01				< .005		
Zn	1.3	.06				.07				.06				.02		
COD				94				120				121				100

TABLE B-9

PLANT: SE, NP, R-S **DATE:** 6-26-73 **TIME:** 1000 **pH:** 7.5 **ALK:**

$FeCl_3$	175	**ALUM** 200	**LO-LIME** 250	**HI-LIME** 425
LIME	80	40	–	–
POLYMER	.5	.5	.5	.5

CONDITIONS: No seawater; no recycles

	ALUM				$FeCl_3$				LO-LIME				HI-LIME			
CONSTITUENT	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**	**RAW**	**C&C**	**F**	**C**
Final pH		7.15				6.95				10.6				11.4		
Turbidity, FTU		13				13				8				3.5		
SS		24.5				26				27				21		
Sludge Yield		353				342				473				700		
HEM	77.8	3.2	1.9	2.3		2.8	1.5	2.3		3.9	2	1.6		4.3	1.6	1.3
BOD	222	72		53		61		45		77		51		84		66
Phenol	.19	.1	.13	< .002		.06	.13	< .002		.17	.19	< .002		.19	.18	< .002
Cd	.005	< .001				< .001				< .001				< .001		
Cr	.84	.023		.017		.014		.017		.021		.015		.013		.024
Cu	.12	.016				.01				.012				.007		
Cn	.033	.022				.029				.027				.023		
Pb	.072	.02				.017				.016				.014		
Mg	31	30				32				24				3.5		
Hg	.0013	.0013		.0012		.0013		.001		.0012		.001		.0012		.001
Ni	.0133	.006				.005				.01				.008		
Ag	.048	.007				.006				.007				.007		
Zn	.07	.051				.052				.043				.021		
COD	766			81				68				81				107

TABLE B-10

CONST. MG/L / DATE	BOD				COD		HEM		PHENOL		NH_3-N		NO_3-N		NO_2-N	
	RAW	PE	ASE	% REM	PE	ASE	PE	ASE	PE	ASE	PE	ASE	PE	ASE	PE	ASE
6-13-73	–	270	58	79	960	72	44	3.9	–	.06	–	–	–	–	–	–
6-18-73	205	81	17	79	360	87	26	2.3	–	.004	–	–	–	–	–	–
6-20-73	–	39	16	51	119	94	2.1	1.2	–	–	–	–	–	–	–	–
6-21-73	499	57	20.5	63	116	110	2.8	2.3	–	.01	19.5	6	–	2.1	–	.074
6-26-73	222	58	32	45	144	80	3.2	1.8	.2	.004	33.5	23.5	.14	2.7	<.005	.03
7-2-73	151	74	11	85	184	67	3.5	1.4	.2	.01	25	–	.32	–	.004	–

PE = Primary Effluent

ASE = Activated Sludge Effluent

adjusting the proper aeration basin "roll" with the aquarium aerators resulted in failure to remove the biological solids from the secondary clarifier. This resulted in the clarifier filling up and a large quantity of solids passing over the weir. This was not because of the condition of the solids, but because of physical or mechanical problems with the unit. The 80 mgd simulated unit was abandoned so that its feed pump could be used to pump return solids from the secondary clarifier to the aeration basin. This somewhat alleviated the problem of solids passing over the weir, and a stable operation could be maintained. However, at night when the laboratory was not manned, return sludge problems were experienced. After return sludge pumping was initiated, the sludge was relatively stable and effluent total suspended solids ranged from 20 to 40 mg/l with a turbid effluent. A check of the effluent alkalinity revealed a decrease from 190 mg/l in the plant effluent to about 20 to 30 mg/l in the activated sludge effluent. This indicated a nitrifying condition in the activated sludge, and the feed rate was changed to reduce the aeration period to 3 hours. The system changed to a limited nitrifying situation, and the effluent alkalinity increased to the 100 mg/l level. Solids carryover still continued to be a problem, and it was difficult to determine whether the cause was mechanical or biological.

Constituent removals across the unit were very good, averaging 75 percent BOD removal from the raw settled sewage and 90 percent from the raw sewage. Grease and oil effluent values were below the Bay requirement of 5 mg/l, as was phenol which was much below the 0.5 mg/l standard.

BENCH SCALE PROGRAM OUTLINE

In reference to the Bench Test Program 2, the solids carry-over is believed to be more of a mechanical problem than biological. In view of the key constituent removals, the process should be considered stable. Because it meets the 85 percent BOD removal, it could have been analyzed for toxicity if there had been sufficient effluent available. But, in view of the BOD removal, it would probably meet the requirement so that it could be considered a candidate process to pilot. Total chromium was not analyzed on the six samples.

One additional test was run on the activated sludge effluent when the system was in the nitrifying stage. At an effluent alkalinity of 18 mg/l, it was difficult in a jar test to achieve the proper base and coagulant dose for simulated chemical coagulation in terms of turbidity and final pH. This is important for the operation of the proposed Train No. 1 physical/chemical process following biological treatment and for controlling optimum chemical dosages.

In reference to Bench Test Program 3, the accumulated data indicate that ferric chloride and lime, when used as primary coagulants to achieve similar effluent solids removals, generally have similar removals for other constituents of concern.

When wastewaters that are difficult to coagulate are encountered, it appears that the Ocean TSS and oil and grease standards can be met by an average ferric chloride dosage of around 150 mg/l for Southeast and 100 mg/l for North Point and Richmond-Sunset wastewaters.

Two computer runs were made to determine the most economical ferric chloride dosage for organic solids removal prior to lime treatment and recalcination. One run was made on the Southeast raw sewage alone and one was made using a simulated composite of all three raw sewages. Unfortunately, because of the high magnesium levels present in the Southeast and North Point raw sewages, the predicted recalcination furnace product of available calcium oxide would be 45 percent for the Southeast alone, and 58 percent for the composite. These are much too low for economic recalcining operations.

The question of economics for the usage of a low ferric chloride dosage and a high lime dosage (pH 11.2) versus an individual high ferric dosage was simulated in a jar test shown in Table B-11. The Southeast raw sewage was coagulated with 20, 40, and 60 mg/l of ferric chloride and 0.5 mg/l of anionic polymer. The best supernatant had a turbidity of 52 FTU and a TSS of 110 mg/l. The supernatant was dosed with 350 mg/l of lime $Ca(OH)_2$ to pH 11.2 and 0.5 mg/l of anionic polymer. The best supernatant had a turbidity of 7.5 FTU and a TSS of 18 mg/l. A separate jar run with only the 350 mg/l of $Ca(OH)_2$ and 0.5 mg/l of polymer raised the pH to 11.2 with a turbidity of 10 FTU and a TSS of 20 mg/l. In reference to Tables B-1 thru B-9 and the similar constituent removals for all coagulants, the two-stage operation is questionable, especially from a capital cost viewpoint.

In reference to Bench Test Program 4 for evaluation of solids handling, the sludges from all raw sewages generally contained the same amount of volatile portion for each coagulant. Ferric chloride and alum sludges

TABLE B-11

PLANT: SE **DATE:** 7-13-73 **TIME:** 1230 **RUN:** 1A **pH:** 7.2

COAGULANT: $FeCl_3$ **BASE:** None **COAGULANT AID:** Dow A-23 **CHLORIDE:** 110 mg/l

CONDITIONS: No Saltwater; No recycles

JAR NO.	1	2	3	4	5	6
Coagulant Dose, mg/l	20	20	40	40	60	60
Base Dose, mg/l	0	0	0	0	0	0
Coagulant Aid, mg/l	0.5	0.5	0.5	0.5	0.5	0.5
Final, pH	7.15	7.15	7.05	7.05	6.9	6.9
Turbidity, FTU	60	–	55	–	52	–
Suspended Solids, mg/l	–	–	–	–	110	–

COAGULANT: Lime **BASE:** None **COAGULANT AID:** Dow A-23

CONDITIONS: The supernatant from jars 1 and 2 of run 1A was used for jar no. 1 of run 1B; jars 3 and 4 of run 1A were used for jar no. 2 of run 1B; jars 5 and 6 of run 1A were used for jar no. 3 of run 1B. Jar no. 10 has not had low ferric chloride treatment.

JAR NO.	7	8	9	10
Coagulant Dose, mg/l	350	350	350	350
Base Dose, mg/l	–	–	–	–
Coagulant Aid, mg/l	0.5	0.5	0.5	0.5
Final, pH	11.2	11.3	11.3	11.2
Turbidity, FTU	6.9	8.3	7.5	10
Suspended Solids, mg/l	–	–	18	20

had volatile percentages ranging from 40 to 60 percent, and the lime sludges were no higher than 30 to 35 percent. Total solids in the jar test sludges were less than 1 percent for all sludges. The total amount of sludges produced, defined as the dry weight of solids produced from 1 liter of raw sewage with coagulants added, are shown in Table B-12. The alum sludge averaged the lowest quantity followed by ferric and lo- and hi-lime.

The magnesium concentrations in the lo-lime sludge appear to be about one-third of those in the hi-lime sludge. The lo-lime operation at pH 10.2 prevents the formation of magnesium hydroxide relatively well, producing the lower quantity of sludge.

The small quantity of sludge produced in the jar testing made it difficult to conduct thickening tests in a graduate cylinder. An attempt was made at thickening by placing hi-lime, ferric, and alum sludges in beakers and decanting the supernatant over a 24-hour period. The solids concentrations of the resultant slurries were hi-lime, 1.8 percent; ferric, 1.1 percent; and alum 1.2 percent.

The filter leaf used was 0.1 sq ft in area with a nylon cloth media. The vacuum was 10 in (25.4 cu) mercury with 1 minute dry and 1 minute submerged times. The hi-lime sludge produced a 55 percent solids cake at a 4.6 lb. dry solids sq ft/hr (0.94 kg/hr/sq m) filter rate. The filtrate had a solids concentration of 0.18 percent. The ferric sludge produced a 33 percent solids cake at a 3.1 lb/hr/sq ft (0.63 kg/hr/sq m) filter rate. The filtrate was 0.08 percent solids. The alum sludge produced a 39 percent

TABLE B-12

SLUDGE YIELDS, MG/L

DATE	PLANT	$FeCl_3$	ALUM	LO-LIME	HI-LIME
5-17-73	SE	272	581	693	1,077
6-6-73	SE	823	487	799	–
6-11-73	NP	251	214	329	466
6-13-73	R-S	302	242	279	466
6-18-73	NP & SE	344	338	502	811
6-21-73	SE	602	596	587	812
6-26-73	NP & SE & R-S	342	353	473	700
6-28-73	SE	322	278	229	874
7-2-73	NP	252	174	316	419
AVERAGE		390	365	467	627

solids cake at a 2.9 lb/sq ft/hr (0.59 kg/hr/sq m) filter rate. The filtrate was 0.09 percent solids.

Pilot plant sludges were also evaluated in the same manner. Table B-13 shows the results of the run on the alum sludges from Train No. 1, ferric sludge from Train No. 2, and lime sludge from Train No. 2A. Unfortunately, during the solids testing period considerable rain fell so the sludges were more diluted than normal. The sludge was thickened by decanting for 24 hours and the filter leaf test was conducted on the four sludges.

The tertiary alum sludge did not thicken or dewater well. The ferric sludge did not thicken as well as the lime or alum (Train No. 3), but it dewatered better. The lime sludge and alum (Train No. 3) sludges thickened and dewatered the best, although all had rather poor efficiencies.

Of particular interest was the fact that the lime sludge would not thicken beyond 4 to 5 percent in the pilot plant gravity thickener or in bench scale beakers. As has been previously stated, the high magnesium concentration in the sludge results in poor thickening and dewatering characteristics. In an effort to evaluate the thickening characteristics further, a sample of the pilot plant gravity thickener underflow was placed in a 1000 ml graduate cylinder which was stirred mechanically at a rate of 1 rpm. Figure B-1 shows the thickening rate over four days from 5.0 percent solids to 12.4 percent solids, where the rate appeared to decrease to zero. About 2 days of gentle stirring were required for the 8 percent figure to be reached.

TABLE B-13

THICKENING AND FILTER LEAF TESTING
NORTH POINT AND SOUTH EAST PERIOD

	TRAIN NO.			
	1 ALUM	2 FERRIC	2A LIME	3 ALUM
Total Solids, %				
Raw Sludge	.38	.54	.85	.35
Thickened	.45	1.22	2.75	1.36
Cake	12.9	18.7	17.9	19.5
Filter Rate, lbs/SF/hr	<1	<1	2.1	<1

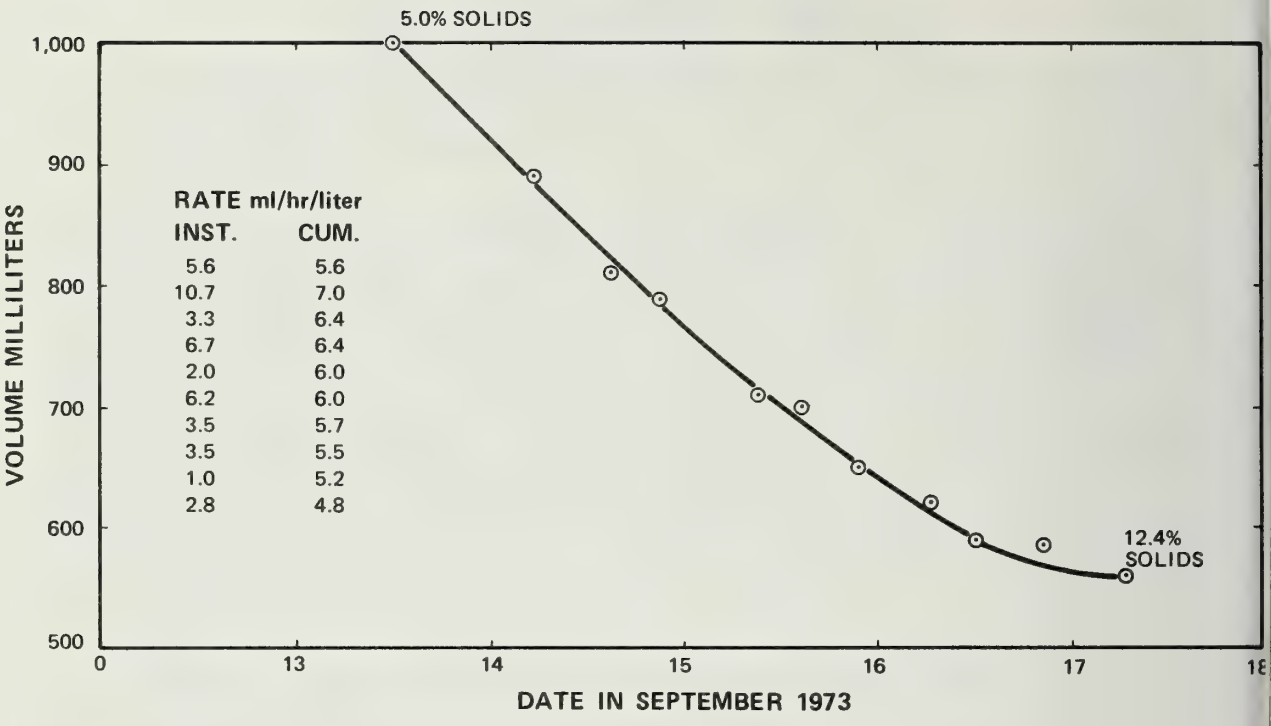


FIGURE B-1

LIME SLUDGE THICKENING
IN 1,000 ML GRADUATE
(stirred-1 rpm)

One attempt was made to recarbonate the jar test hi-lime sludge from pH 11.2 to 10.2 in order to resolubalize the magnesium hydroxide and hopefully make the sludge more amenable to thickening, dewatering, and recalcining. The jar test raw sewage had a magnesium concentration of 83 mg/l. After hi-lime coagulation and clarification, the jar test supernatant had a magnesium concentration of 8 mg/l and the sludge 1300 mg/l. After recarbonation, the supernatant had 240 mg/l and the sludge 960 mg/l. There obviously was a positive effect for magnesium removal, but whether it was sufficient to provide a better sludge for dewatering and recalcining is doubtful. If lime were to be a coagulant of choice for a full scale plant, the sludge recarbonation process would be an excellent area for further research.

In reference to Bench Test Program 5, the results of the 12 bihourly jar tests using ferric chloride, alum, lo- and hi-lime on the Southeast raw sewage are shown on Figures 2 and 3. The full scale plant intentional saltwater addition was turned off during this period. The plant solids handling recycles were added in a ratio to simulate the conditions presently encountered at the plant, which was solids from 80 mgd of raw sewage recycled to 20 mgd of raw sewage.

During the first day of testing, a raw sewage sample with a pH of 11.4 was encountered and resulted in a significant "blip" on the graphs. Otherwise the pH ranged between 6 and 8 for the period. The average optimum ferric dosage was about 200 mg/l, producing a turbidity of 5 FTU and

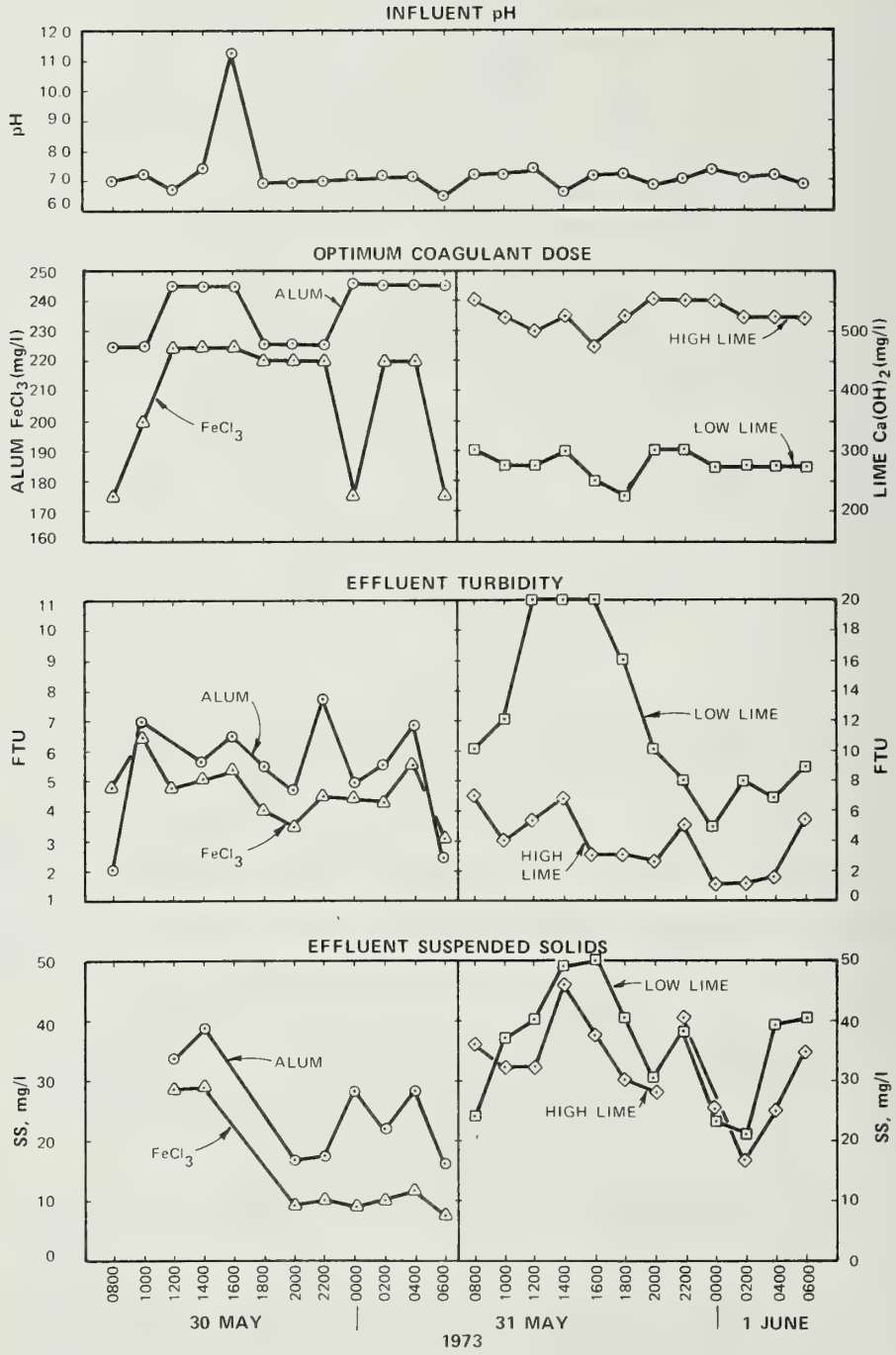
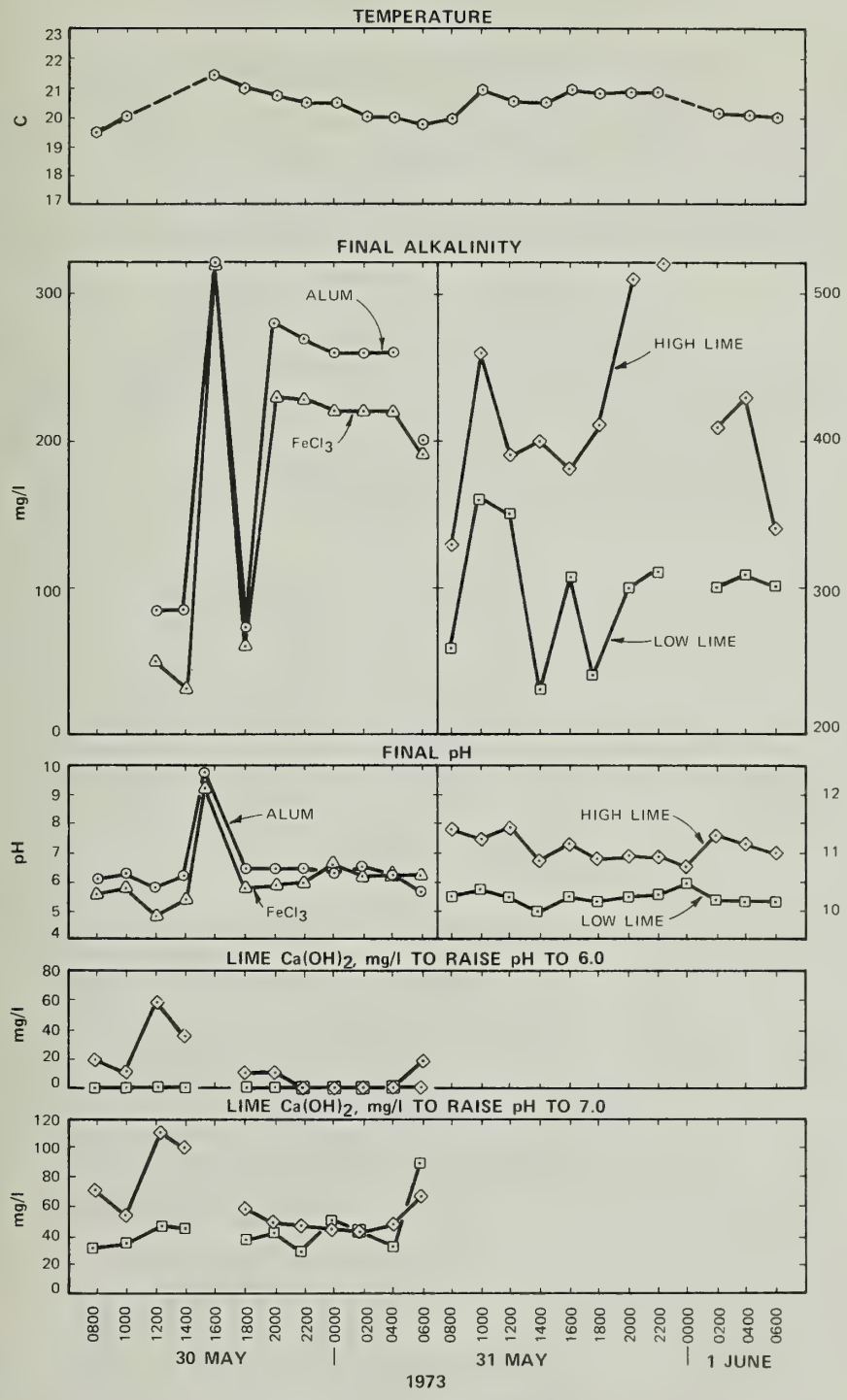


FIGURE B-2

COAGULATION OF RAW SEWAGE
WITH 0.5 mg/l DOW A23 WITHOUT
FILTRATION AT SOUTHEAST PLANT



NOTE: $FeCl_3$ WITH 5 mg/l DOW A-23, NO BASE
ALUM WITH 5 mg/l SE

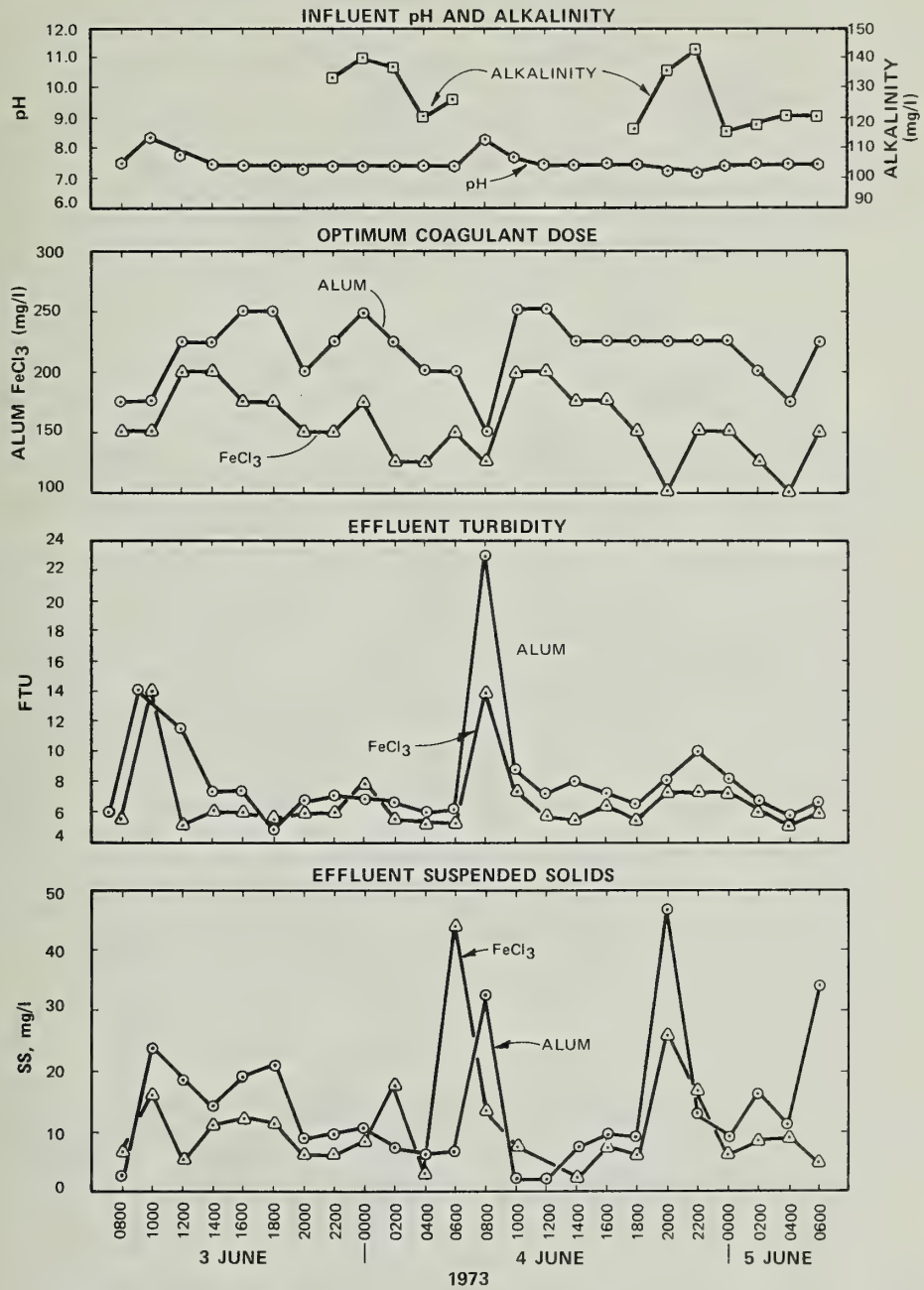
FIGURE B-3
TWENTY-FOUR HOUR RAW SEWAGE COAGULATION

about 15 mg/l TSS. The final alkalinity and pH were considerably affected by the high pH waste dump. The final pH ranged from 5 to 7. It required about 20 mg/l of lime to raise the pH to 6.0 and 70 mg/l to raise the pH to 7.0.

The average optimum alum dosage was about 235 mg/l, producing a turbidity of 6 FTU and about 25 mg/l TSS. The final pH ranged from 5.9 to 7.0. About 40 mg/l of lime were required to raise the effluent to a pH of 7.0.

The average optimum lo-lime dosage was around 275 mg/l lime producing an effluent turbidity of about 12 FTU and 35 mg/l TSS. The average hi-lime dosage was about 525 mg/l $Ca(OH)_2$ producing an effluent turbidity of about 5 FTU and 30 mg/l TSS.

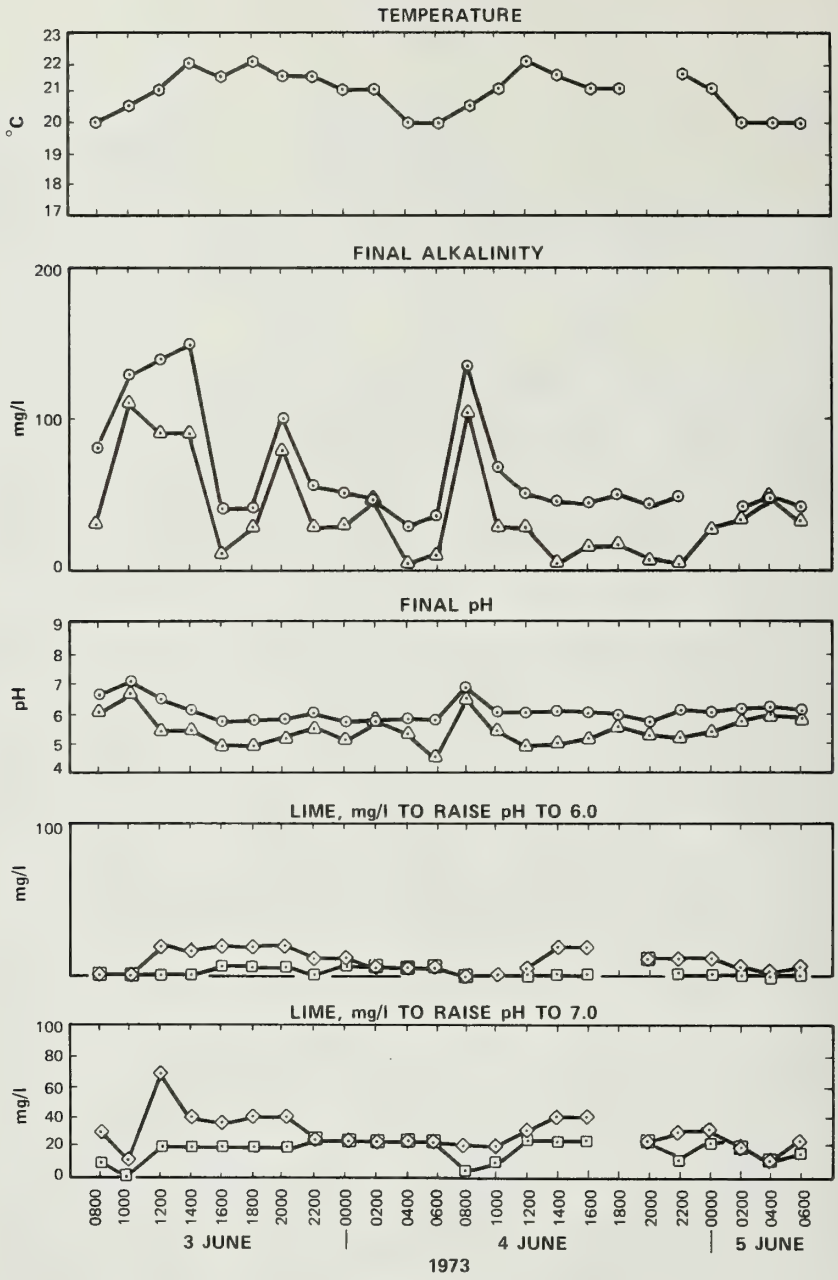
The results of 24 bihourly jar tests on the Richmond-Sunset raw sewage with ferric chloride and alum are shown on Figures B-4 and B-5. Lime was not jar tested because of space limitations with its use at full scale. The influent alkalinity ranged from 115 to 150 mg/l and the pH ranged from 7.0 to 8.5. The average optimum ferric dosage ranged from 150 to 175 mg/l producing an effluent turbidity of 7 FTU and about 15 mg/l TSS. The final alkalinity ranged from 5 to 110 mg/l, which is very critical in terms of depleting the alkalinity and subsequent coagulation problems. The final pH ranged from 4.5 to 6.5, and an average of 10 mg/l of lime were required to raise the effluent to 6.0 and 25 mg/l to raise it to 7.0.



NOTE: COAGULANT AID – DOW A-23 AT 0.5 mg/l

FIGURE B-4

COAGULATION OF RAW SEWAGE
WITHOUT FILTRATION OR ADSORPTION AT
RICHMOND-SUNSET PLANT



NOTE: $FeCl_3$ WITH .5 mg/l DOW A-23, NO BASE R-S
$FeCl_3$ WITH .5 mg/l DOW A-23, NO BASE R-S

FIGURE B-5

TWENTY-FOUR HOUR RAW SEWAGE COAGULATION

BENCH SCALE PROGRAM OUTLINE

The average optimum alum dosage was about 225 mg/l, producing an effluent turbidity of about 8 FTU and about 15 mg/l TSS. The final alkalinity ranged from 30 to 130 mg/l with the pH between 5.8 and 7.0 It required about 20 mg/l of lime to raise the effluent pH to 7.0.

ADDITIONAL BENCH STUDIES

One run was made on the Southeast raw sewage to simulate wet weather conditions. The standard raw sewage mixture with recycle was made up. Two liters of the mixture were combined with six liters of tap water. The pH of the resulting mixture was 7.6 and the turbidity was 32 FTU. The seawater addition was on at the time the sample was taken, and therefore the results did not show the effects of overdosage. Twenty-five mg/l of ferric chloride and 10 mg/l of lime with no polymer reduced the turbidity to 4.5 FTU. Forty mg/l of alum and 10 mg/l of lime also reduced the turbidity to 4.5 FTU.

One run was made to simulate discharge of the ferric chloride, alum, and hi-lime coagulation and clarification supernatants to the Bay. The ferric chloride supernatant had a pH of 7.3 and a turbidity of 6.5 FTU. The alum supernatant had a pH of 7.1 and a turbidity of 4.2 FTU. The hi-lime supernatant had a pH of 11.2 and a turbidity of 5.0 FTU. The bay water had a pH of 7.0 and a turbidity of 8.5 FTU. Nine hundred milliliters of bay water were mixed with 100 mls of each supernatant. The resultant mixture of each assumed the characteristics of the bay water. A small deposit, probably post precipitation,

formed on the bottom of the jar, but when stirred into suspension it did not affect the turbidity.

The effect of prechlorination on coagulation was evaluated in two jar tests utilizing ferric chloride and alum with lime and anionic polymer. In each run with the same raw sewage, two sets of identical dosages for each coagulant were set up. The second set of each coagulant had 10 mg/l of chlorine added to each beaker prior to the addition of the base and primary coagulants. Prechlorination at the above dosage lowered the final turbidity about 3 to 4 FTU.

Three runs were made on the Southeast raw sewage to evaluate the effects of using ferric chloride, alum, and activated silica as coagulant aids with hi-lime (pH 11.2) as the primary coagulant. The anionic polymer at a dosage of 0.5 mg/l was added to the ferric chloride and alum beakers only. Although the supernatant of all beakers was 12 FTU or less, the activated silica at a 10 mg/l dosage equaled the highest ferric dosage of 75 mg/l in terms of turbidity at 6.5 FTU. The hi-lime with only the activated silica as the coagulant aid performed very well and had the most compact sludge. The alum appeared to increase the final turbidity with higher dosages. Supernatant samples were refrigerated overnight and the turbidities read again with no difference in the original value.

Finally, several runs were made to determine the effect of reducing the jar test 30-minute clarification period to 5 minutes. Supernatant samples decanted from the beakers after 5 minutes were no different, relatively speaking, than after 30 minutes with the well-coagulated samples.

In other words, once the optimum dosage is determined and the rapid mix and flocculation times are completed, there is no increase in removal of collodial material in the extended clarification period.

APPENDIX C

APPENDIX C

DEVELOPMENT OF "COEFFICIENT OF RELIABILITY"

The Coefficient of Reliability was developed by the San Francisco Department of Public Works. It is a technique whereby the constituent removal characteristics of several treatment processes can be measured, examined, and compared.

The Coefficient of Reliability (Cr) is an arbitrary number which has the limits of $-\infty$ to ∞. Cr defines the range and displacement in which 80 percent of experimental data will fall.

The following procedure was used in interpretation of all real data obtained under the pilot plant study. This material is copied from the project agreement.

DEFINITIONS

R = Range of values which fall between 10 percent and 90 percent probability for any constituent.

d = Displacement between the requirement value and the 90 percent experimental value.

The Coefficient of Reliability (Cr) is defined as the following relationship:

$$Cr = \frac{1}{R} \cdot d$$

PROCEDURE

1. A minimum of 24 sample data will be obtained from a set condition of pilot plant operation for each process step.

2. Raw data values will be ranked in descending order.

3. The percent frequency will be determined when an experimental value is greater than or equal to itself, when compared to all values obtained for the given situation.

4. Plot data and frequency as shown in example. (Attached) (Data plotting not required during CH2M HILL computer processing)

5. Draw best curve through points. (Data plotting not required during CH2M HILL computer processing)

6. Indicate required value. (e.g., Ocean Discharge Requirement for the constituent)

7. Select test frequency range 10 percent to 90 percent.

8. Determine "R" in the selected frequency range by subtracting the low value (10 percent) on the best curve in the range of frequency from the highest value (90 percent) in this range.

9. Determine "d" by subtracting from the requirement value the closest experimental value (90 percent).

10. Compute Cr for process

$$Cr = \frac{1}{R} \cdot d$$

11. Compute Cr for the other constituents.

12. The largest positive value of Cr for a given process indicates the most reliable process.

13. Data is to be tabulated as shown in example.

14. Data processing may be used in computation of "Coefficients of Reliability".

6. Calculate Cr

$$Cr = \frac{1}{R} \cdot d$$

In this case: $R = 15$, $d = 8$

$$Cr = \frac{1}{15} \cdot 8 = 0.667$$

7. If the requirement in this case was 32 mg/l, the Cr would be 0. Negative values of d are possible giving a negative value for Cr which would mean not all data in 80% limits would meet requirement. By adjusting the limits it is possible to predict which % of all values will meet a requirement.

8. All "Coefficient of Reliability" to be presented in this form.

FINAL DATA REDUCTION

PROCESS STEP	CONSTITUENT				
	A	B	C	D	ETC.
I	Cr				
II					
III a					
III b					
III c					

APPENDIX D

APPENDIX D

APPENDIX D-1

Analytical Procedures

APPENDIX D-2

Richmond-Sunset Sedimentation
Basin Flow Measurement

APPENDIX D-1

ANALYTICAL PROCEDURES

	Page
General	1
Nonstandard Method Verification	3
Laboratory Duplication	4

Attachment A. LFE
Environmental, Analysis
Laboratories Division, 13 June 1973

Attachment B. CH2M HILL
Memorandum to Mr. A.O. Friedland,
8 June 1973

APPENDIX D-1

ANALYTICAL PROCEDURES

GENERAL

During the Southeast and North Point-Southeast phases of the San Francisco Pilot Plant Study constituent and process data were generated by eight participating laboratories. All commercial laboratories which conducted analyses were certified by the California State Health Department. The analytical laboratories utilized during the study, in order of total analyses performed, were as follows:

1. L.F.E. Environmental Laboratory
2. CH2M Hill Mobile Laboratory
3. F.M.C. Corporation Laboratory
4. Cook Research Laboratories, Inc.
5. San Francisco Operational Laboratories
6. American Spectrographic Laboratory
7. Bechtel Corporation Laboratory
8. California State Public Health Laboratory

L.F.E. Environmental Laboratory, Richmond, California, was responsible for the majority of constituent analyses obtained during the pilot plant operations. At the completion of the Southeast and North Point-Southeast pilot plant programs over 7,000 separate chemical analyses of wastewater had been conducted by the laboratory. The CH2M HILL Mobile Laboratory

performed all operational testing and bench-scale studies during the pilot plant program. F.M.C. Corporation Laboratory provided all total organic carbon analyses during the study. Cook Research Laboratory, Bechtel Corporation Laboratory and the California State Public Health Laboratory testing was limited to cross-checking data with the L.F.E. and CH2M HILL Laboratories. American Spectrographic Laboratory conducted emission spectrographic analyses of selected samples for semi-quantitative measurements of metals. The San Francisco Operational Laboratories contributed by some duplication of L.F.E.'s and CH2M HILL's testing and by providing routine plant operational data for correlation with pilot plant analyses.

Sampling, sample management, and chemical testing conducted during the pilot plant operations was performed by accepted, standard procedures. All chemical or physical analyses of wastewater was carried out in compliance with one or more of the following references:

1. Standard Methods for the Examination of Water and Wastewater. 13th edition.

2. Guidelines for Technical Reports and Monitoring Programs. Water Quality Control Plan: Ocean Waters of California.

3. Methods for Chemical Analysis of Water and Wastes. EPA 1971.

4. Federal Register. Vol. 38 No. 199. EPA Water Programs: Guidelines Establishing Test Procedures for Analysis of Pollutants.

5. Annual Book of Standards, Part 23, Water Atmospheric Analysis, 1972. A.S.T.M.

6. Accepted Instrumental Methods. Employing Standard Applications. (Atomic Adsorption Spectrophotometer, Visual-U.V. Spectrophotometer, Specific ion Electrodes, etc.

7. Other accepted, tested, and published analytical procedures (Hatch techniques, manufacturer's directions, radioactive proprietary techniques).

As the majority of constituent analyses were performed by L.F.E. Environmental Laboratories, a complete review of their analytical practices and procedures was conducted. CH2M HILL chemists and pilot plant personnel met with L.F.E. staff on several occasions to establish the accepted analytical methods and proper laboratory procedures for each constituent to be analyzed during the pilot plant study. A statement of the agreed upon methodology for each constituent was transmitted from L.F.E. to CH2M HILL on June 13, 1973. (See attachment)

NONSTANDARD METHOD VERIFICATION

Many of the constituents which were studied during the pilot plant program could be analyzed by several accepted wet-chemistry and instrumental methods. In addition, several of the constituents could be analyzed by recently published, widely used methods which had not yet been accepted by Standard Methods or the regulatory agencies. Some of these newer methods were generally acknowledged to produce more accurate results in a shorter period of time. To guarantee a consistency of analytical results, a system of cross checking was developed. Regardless of the chemical method normally employed, ten percent of all samples and constituents were analyzed by means of accepted regulatory, wet-chemistry procedures. In most instances this sample duplication and constituent cross-checking was accomplished using Standard Methods for the Examination of Water and Wastewater, 13th edition, as a

reference. Constituent verification was randomly performed and the duplicated results had to consistenly be within ten percent for the nonstandard method to be continued. The largest percentage of nonstandard method testing occurred through the use of automated and instrumental techniques, such as specific ion probes and atomic adsorption.

In addition to the cross-checking of different analytical procedures and commercial laboratory duplications, internal standards were frequently used to measure the efficiency of each analytical procedure. The internal standard technique employs the addition of a known amount of the constituent to be analyzed to the unknown sample. At the completion of the test the constituent result should reflect the added concentration. If the resultant concentration is less than the addition, interferences in the test procedure are present and corrective action must be taken. Corrective action can involve the removal of interferences prior to testing or the use of other analytical procedures which are not subject to the interference.

LABORATORY DUPLICATION

Approximately 5 percent of all analyses were duplicated by means of split samples to one or more commercial laboratories. Table D-1 shows the result of a duplication series conducted between two laboratories for copper during the sampling program.

TABLE D-1

Sample Ident.	Cu mg/l L.F.E.	Cook
041673	0.23	0.16
042473	0.24	0.31
041873	0.14	--
042673	0.20	0.42
042073	0.12	0.32
042873	0.20	0.18
042273	0.29	0.21

While the majority of samples split between laboratories exhibited a high degree of correlation, such as copper, certain "problem constituents" were identified. These "problem constituents" varied greatly between laboratories when split samples were analyzed. The most difficult analyses to duplicate from wastewater subsamples appear to be oil and grease (HEM), floatables, biological oxygen demand (BOD) and chemical oxygen demand (COD). Table D-2 presents the results of a COD laboratory duplication study. A wide discrepancy in the split sample, analytical results is evident.

TABLE D-2
COD mg/l

		Laboratory		
Date	Station	L.F.E.	Cook	Bechtel
10-24-73	9	63.4	27	
	12	91.2	17	
	16	155	98	
	23	172	102	
	30	12.4	63	
10-25-73	9	176	37	
	12	107	30	
	16	107	80	
	23	139	122	
	30	87.4	42	
10-26-73	9	23.8	57	50.7
	12	48	69	36.2
	16	96.9	146	58
	23	135	132	51.5
	30	46.4	76	47.0

The results of an oil and grease duplication study is shown in Table D-3. In this study a single sample of Southeast Treatment Plant effluent was split eight ways and randomly distributed to the testing laboratories.

TABLE D-3
Oil and Grease (HEM) mg/l

Aliquot No.	Laboratory	Result
1	Cook Research	12
2	State Public Health	3.7
3	L.F.E. Environmental	28
4	State Public Health	3.7
5	State Public Health	Sample Lost
6	L.F.E. Environmental	100
7	Cook Research	11
8	L.F.E. Environmental	22

The complete answer as to why it is difficult, if not impossible, to obtain a high statistical correlation of duplicated samples for these "problem constituents" is not fully understood. Several possible explanations have been proposed which appear to answer some of the anomalies:

1. Sample Splitting Problems. Many of the raw sewage and primary-treated effluents contain a proportion of solids. These nonhomogeneous samples may make it impossible to obtain a truly representative aliquot and hence each subsample analyzed is really different. This does not account for anomalies in data generated from highly treated effluent sample splitting.

2. Variations in Analytical Technique or Sample Handling Procedure. Within Standard Methods 13th edition there are often more than one approved method and within a given method there are frequently alternatives of apparatus or chemicals to be employed. In the case of oil and grease analyses shown above, a review of the acceptable procedures was made. The results of this review indicated that there are three State acceptable procedures and two solvents which can be employed. This produces six different

acceptable methodologies under which oil and grease can be analyzed. A complete description of the review of oil and grease analyses was conveyed by memo to the City on 8 June 1973. This memo is included in Attachment D-B. Unfortunately, possible data anomalies caused by variations of approved chemical techniques do not explain certain "problem constituents" where only one, clearly defined procedure was used.

3. Analytical Interferences. Standard Methods 13th edition and Methods for Chemical Analysis of Water and Wastes 1971 describe possible interferences for most constituent testing conducted during the pilot plant study. Where interferences were suspect or measured, sample pretreatment techniques were employed to reduce or alleviate the interfering constituents. Because of the basic characteristic of the influent wastes, however, techniques to remove interferences were not always successful.

As was identified during the Influent Characterization Program, both the North Point and Southeast influents contained a significant amount of sea water. Anomalies in COD values reported for carbon column influents and effluents and discrepancies of analytical results from split samples between different laboratories (Table D-2) could be explained in part by the following quotation from Methods for Chemical Analysis of Water and Wastes 1971 published by the EPA:

> When the chloride level exceeds 1,000 mg/l, the minimum accepted value for the COD will be 250 mg/l. COD levels which fall below this value are highly questionable because of the high chloride correction which must be made.

As evident from the results of COD for several locations within the pilot plant, values frequently were less than 250 mg/l. All of these data must then be considered only approximations of the actual COD concentration.

Other constituent analyses have been identified which exhibit sea water interferences (e.g., A.A.S. determination of metals). The techniques for reducing the interference also lessens the sensitivity of these tests, but apparently not as much as with the COD analysis.

ATTACHMENT A

LFE CORPORATION

LFE ENVIRONMENTAL
ANALYSIS LABORATORIES DIVISION
2030 WRIGHT AVE. • RICHMOND, CALIFORNIA 94804

(415) 235-2633
(TWX) 910-382-8132

June 13,1973
Our Ref: S101072 & S36073

Mr. Lawrence E. Birke, Jr.
Manager, Environmental Sciences
CH_2M/Hill
360 Pine Street
San Francisco, California 94104

Dear Mr. Birke:

This is to confirm our discussions Wednesday, June 6, 1973, and previously, concerning analytical procedures to be used in the San Francisco Sewage Treatment Pilot Plant project currently underway. With reference to my letter of March 22, 1973, LFE restates that all analyses will be performed according to standard methods as established with CH_2M/Hill. Any deviation from this policy will occur only with prior discussions and written consent by CH_2M/Hill.

Attached is a list of all water analyses considered for the project to date, and a specific reference to the method of use.

I would like to confirm also LFE's understanding of the critical importance of analytical data to the Pilot Plant Project. LFE strives to give the best results possible using the most accepted, standard, and professional analytical techniques, as established with the customer. We will be happy to review and evaluate procedures, data, and results with CH_2M/Hill on a continuing basis.

I would like to thank you for your continued assistance and close working relationship with LFE Environmental. LFE values participation in your project very highly and looks forward with great interest to continued involvement.

Very truly yours,

David E. Claridge

David E. Claridge, Manager
Environmental Sciences Department

DEC/df

Attachments

TABLE OF PROCEDURES
TWO-WEEK INFLUENT STUDY

Analysis	Method	Standard Methods 13th Edition Page No.	Comments
As	SM	62	Samples were concentrated from 1 l with H_2SO_4 HNO_3 evaporation. Pb Ac trap is eliminated.
Be	SM	210	Note 1.
Cd	SM	210	AAS. Note 1.
Cr.	SM	210	AAS. Note 1.
Co	AAS	*	AAS. Note 1.
Cu	SM	210	AAS. Note 1.
Pb	SM	210	AAS. Note 1.
Mn	SM	210	AAS. Note 1.
Hg	Flameless AAS	*	Hatch & Ott AC 40, 2085 (1968)
Se	SM	296	
Ti	H_2O_2 (Sandell)	*	Reference 1. Note 1.
V	AAS	**	AAS. Note 1.
Zr	Thorin (Snell & Snell)	*	Reference 2. Note 1.
U	Fluorimetric	*	Jarrell-Ash Instrument Procedure
Cr^{+6}	SM	156	S diphenyl carbaside. Read in Hellige color comparator to obtain

Note 1: Concentrated by precipitation with CaO. (Ref. 1) Run on Perkin Elmer 303 AAS.

Reference 1: Sandell "Colorimetric Metal Analysis" 3rd Ed. Interscience 1959.

Reference 2: Snell and Snell, "Colorimetric Methods of Analysis" Vol IIA, Van Hostrand, 1959

SM = Standard Methods, 13th Edition

* Not in Standard Methods, 13th Edition

** Procedure in Standard Methods, but alternate procedure used as indicated.

Analysis	Method	Standard Methods 13th Edition Page No.	Comments
Acidity	SM	50	
Alkalinity	SM	82	Brom cresol green - methyl red indicator
BOD-5 day DO	SM	489, 484	
BOD-Ultimate	Wesson & Stack	*	5 day BOD samples retained and DO determined by probe method at intervals until maximum DO depletion was attained.
CO_2	SM	92	
CL	SM	97	Mercuric Nitrate
COD	SM	495	
I	LFE	**	Schnepfe, Anal. Chim Acta 58, 83(1972)
Oil & Grease	LFE	**	Modified combination of SM p. 254 & 409: Mechanical mixing of total raw sewage sample with hexane
$SO_4^=$	SM	334	Hach Turbidimeter
SO_3	SM	337	
$S^=$	SM	552	
Nitrogen:			
NH_4	SIE	**	Per manufacturers (Orion) directions for NH_3
Organic	SIE	**	Per manufacturers (Orion) directions for NH_3
Kjeldahl	SIE	**	Per manufacturers (Orion) directions for NH_3
NO_3	SM	461	
NO_2	SM	240	Clarified with carbon prior to analysis
PO_4-Ortho	SM	527	Vanadomolybdophosphoric Acid

* Not in Standard Methods, 13th Edition

** Procedure in Standard Methods, but alternate procedure used as indicated.

Analysis	Method	Standard Methods 13th Edition Page No.	Comments
PO_4-Total	SM	527, 524	Perchloric acid digestion
Floatables	LFE	*	The floatable material from the settleable solid determination was collected and weighed.
Solids			
Settleable	SM	539	
Tot. Suspended	SM	537	Glass Fiber Filters
Vol. Suspended	SM	538	
Total Dissolved	SM	290	
Total Solids	Addition		Addition of dissolved solid and suspended solid
Tot. Vol. Solid	Addition		Addition of volatile dissolved solid and volatile suspended solid
Turbidity	SM	351	Hach Turbidimeter
Color	SM	160	Hellige Color Comparator
Conductivity	SM	326	Platinum Electrode
Gross Alpha	SM	583, 598	Modification: After evaporation the sample is ashed and the subsequent ash acid slurried to the planchet.
Gross Beta	SM	583, 598	Same as gross alpha.
Strontium-90	LFE	**	See attached method.
Radium-226	SM	617	Modification: replaced dry ashing with $HCLO_4$-AI metathesis of $BaSO_4$.
Pesticides		**	See attached Methods.

* Not in Standard Methods, 13th Edition

** Procedure in Standard Methods, but alternate procedure used as indicated.

STRONTIUM-90 METHOD

The total sample was evaporated and ashed in the presence of Y carrier. When ^{90}Sr-^{90}Y equilibrium was reached, the ash was solubilized and ^{90}Y extracted into di-(2-ethylhexyl) phosphoric acid (HDEHD) at pH 1. The yttrium was back extracted with 3 N HNO_3, precipitated as a fluoride and mounted for counting as the oxalate.

^{90}Y purity was ascertained by decay with daily counts. The counting efficiency used was that of an Amersham-Searle ^{90}Sr-^{90}Y certified standard.

PESTICIDE ANALYSIS METHODS

Pesticides were analyzed by a number of standard procedures as described below:

Organochlorine and thiophosphate pesticides method used for analysis is the one adopted as the EPA official method and is presented in their bulletin "Methods for Organic Pesticides in Water and Wastewater-1971"

Cerbamates analyzed using the method described by Khalife and Mumma in the Journal of Agricultural Food Chemistry, Vol. 20, No. 2, 1972 (Separation obtained in second fraction per reference above, EPA.)

2,4D compounds analyzed using the F.D.A. method as described in "Pesticide Analytical Manual," Vol.1 (Separate aliquot)

PCB's separated and analyzed using the method described by Armour and Burke in the Journal of the Assc. of Official Analytical Chemists (Vol. 53, No. 4, 1970).

PESTICIDE ANALYSIS PROCEDURE

I. EXTRACTION

1. Using paper towels or coarse filter paper, filter 2 1-liter aliquots into labelled bottles. One aliquot is for 2, 4D compounds, the second is for the other compounds to be determined. 2, 4D procedure is in Section IV.

2. Begin blank samples with each set and use exactly the same procedure for blanks and samples. If desired, internal spikes can be added to samples at this point.

3. In a 2-liter separatory funnel, extract the sample first with 60 ml of 15% ethyl ether in hexane. Be sure to rinse the original sample container with the organics before adding them to the funnel. Shake well (~4 min) and vent often. Water is drained into original container. The organic layer and any emulsion are centrifuged and the clear top layer is pipetted into a drying tube which contains 2-3" Na_2SO_4. The dried sample is collected in a 500 ml round bottom flask. (Note: The drying tube is pre-wet with ~10 ml hexane, which is discarded. Use the same drying tube for all 3 extractions.)

4. Step 3 is repeated and the second extract combined with the first.

5. Add 35 ml of saturated Na_2SO_4 water to the water sample and mix well.

6. Extract a third time with 60 ml pure hexane, centrifuge, dry and add to the r. b. flask. Rinse the drying tube with ~10 ml hexane and add this to the flask also.

II. CONCENTRATION AND FLORISIL COLUMN SEPARATION

1. Combined extracts should be concentrated to ~10 ml using rotary evaporator with water bath at ~60° C.

2. Florisil clean-up and separation

   a. Column preparation - placed 4" of activated (at 130° C overnight) Florisil in a column containing a bottom stopcock and sintered disc. Top this with ~1" Na_2SO_4.

b. Column is pre-wet with 40-50 ml hexane, which is discarded. Close stopcock just as the liquid level reaches the top of the Na_2SO_4. Add the sample slowly - do not disturb the column surface. Allow the liquid level to again reach the top of the Na_2SO_4 and close the stopcock.

c. Begin the first elution using 200 ml of 6% ethyl ether in hexane (v/v) which is premixed and placed in a stoppered separatory flask above the column. Collect 200 ml in a calibrated receiver then close the stopcock. Collection rate is ~5 ml/min. This portion A, and contains most chlorinated pesticides and PCB's.

d. Begin the second elution using 200 ml of 15% ethyl ether in hexane. Collect 200 ml in a calibrated receiver, then close the stopcock. Discard any solvent remaining in the column. This elution is portion B and contains phosphate pesticides and carbamates.

e. Portion A is concentrated to 2-4 ml in Kuderna-Danish glassware and analyzed on the G-C. If there is high PCB levels a silicic acid-Celite column separation must be used. If not, this portion of the analysis is complete.

f. Portion B is concentrated on the rotary evaporator (with water bath at ~60° C) to 3-5 ml volume and run on the G-C. It is then saved for carbamate modification.

III. REMOVAL OF PCB'S FROM PORTION A

1. Column preparation

a. Silicic acid is placed 1" deep in an open beaker and heated ≥ 7 hrs. in a 130° C oven. Beaker is then cooled to room temp. in a desiccator. Quickly weigh silicic acid into glass stoppered bottle and add 3% H_2O using a pipette. Bottle is tightly stoppered and sealed with tape. Shake well until all H_2O is absorbed and no lumps remain. Place in desiccator for 15 hrs. Return container to desiccator after each use. Activation lasts 5 days.

b. Weight 5 g Celite, 20 g activated silicic acid and combine in a 250 ml beaker. Slurry with 80 ml pet. ether, mixing well. Pour slurry into chrom. column with stopcock open, rinsing beaker with small portions of pet ether. Apply air pressure as necessary to force enough pet. ether from column to allow space for the gel mix. Stir with glass rod to move air bubbles. Close stopcock when air is not being applied. Apply air until pet. ether level is ~3 mm above gel surface. Do not allow column to go dry or crack.

2. Place 250 cc volumetric under the column. Add 5 ml sample to the column slowly. Do not disturb top of adsorbent. Apply slight air pressure until sample is ~3 mm above adsorbent. Rinse walls of sample container and add those to the column.

3. Add a sep. flask to the top of the column which contains 250 ml pet. ether, open stopcock and add air pressure to establish an elution rate of 5 cc/min. Stop elution at 250 cc. This is the PCB portion. Concentrate to 1-5 ml and analyze for PCB's if desired.

4. When pet. ether is ~3 mm above adsorbent level add 200 ml acetonitrile-hexane-methylene-chloride (1 + 19 + 80) to reservoir, open stopcock, add air pressure and elute at 5 cc/min. Collect 200 ml volumetrically and reduce this to about 1 ml on K-D glassware or the rotary evaporator. Carefully evaporate at low temperature just to dryness to eliminate all methylene chloride. Add 1-5 ml pet. ether to take up the sample and inject into the G-C for pesticide analysis.

IV. 2,4D CLASS ANALYSIS

1. Use a separate 1-liter water sample for this analysis. Run 1 blank with each set of 6 samples.

2. In a 2-liter sep. funnel extract the sample with a solution of 10 ml 10% aq. H_2SO_4, 25 ml ethanol, 50 ml pet. ether and 150 ml ethyl ether. Shake well and allow to separate. Dry the organic layer through Na_2SO_4 (~ 1" in disposable column).

3. Add this organic solution to a sep. funnel and also add 75 ml of 4% Na_2CO_3. Shake well and separate the 2 layers. The carbonate layer is washed twice with 25 ml portions of ether. The combined 3 ether portions contain any esters and can be concentrated to ~3 ml and analyzed as is on GC.

4. The carbonate portion is placed in a sep. funnel and 40 ml $CHCl_3$ is added and shaken. The chloroform is then discarded. The carbonate solution is then acidified with ~30 ml 10% aq. H_2SO_4. Vent often.

5. This solution is extracted 3 times with 30 ml $CHCl_3$. Combined extracts are evaporated on a steam bath just to dryness, removing the last traces of $CHCl_3$ with ether and an air jet.

6. Pick up acids in 4 ml ether and methylate them with 2 ml diazomethane.

V. CARBAMATE MODIFICATION

1. Portion B is saved or placed in a vial with $\geq$10 ml capacity. To each one is added 0.2-0.4 ml anhydrous pyridine and 0.3 ml trifluoroacetic anhydride. The vials are well shaken and allowed to stand for 10-15 min.

2. At least 5 ml of distilled water is added to each vial and the vial is shaken until the top (organic) layer is clear. Inject a sample from the top layer into the GC for analysis.

TABLE OF PROCEDURES

BENCH SCALE TREATMENT STUDIES

Analysis	Method	Standard Methods 13th Edition Page No.	Comments
Al	SM	210	AAS. Note 1.
B	SM	69	
Ca	AAS	**	
CN	SIE	**	Orion Specific Ion Electrode
Fe	AAS	210	AAS. Note 1.
Mg	SM	210	
Mo	Sandell	*	Reference 1. Colorimetric thiocyanate
Ni	AAS	**	AAS. Note 1.
K	AAS	**	AAS
Si	SM	306	
Na	AAS	**	AAS
Sr	AAS	**	AAS
Zn	SM	210	AAS. Note 1.
Au	AAS	*	AAS. Note 1.
Br	SIE	**	Selective Ion Electrode - Corning
DO	SM	477	
F^-	SM	172	Selective Ion Electrode - Corning
pH	SM	277	
Phenol	SM	222	
Surfactant	SM	339	
Hardness	SM	179	

Note 1: Concentrated by precipitation with CaO. (Ref. 1) Run on Perkin Elmer 303 AAS.

Reference 1: Sandell "Colorimetric Metal Analysis" 3rd Ed. Interscience 1959, p. 644

SM = Standard Methods, 13th Edition

* Not in Standard Methods, 13th Edition

** Procedure in Standard Methods, but alternate procedure used as indicated.

ATTACHMENT B

ENGINEERS PLANNERS ECONOMISTS

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San Francisco Regional Office

8 June 1973

F7722.61
Your File No.6.1.10

MEMORANDUM -

TO: Mr. A. O. Friedland

FROM: Archie H. Rice

SUBJECT: OIL AND GREASE (HEM) ANALYSES

As reported at the last progress meeting, there has been considerable concern regarding the variances which we have obtained from oil and grease analyses for both the influent characterization program and the bench scale studies. To resolve some of these discrepancies and to understand more fully the standard deviation of laboratory analyses for oil and grease, we have obtained a sample of Southeast Sewage Treatment Plant effluent and split it eight ways. These aliquots were then randomly divided between LFE Environmental Laboratory, Cook Research Laboratory and the State Public Health Laboratory. The results of this study have been reported and are as follows:

Sample No. 1.	100	mg/l	LFE Environmental Laboratory
Sample No. 2.	28	mg/l	LFE Environmental Laboratory
Sample No. 3.	22	mg/l	LFE Environmental Laboratory
Sample No. 4.	12	mg/l	Cook Research Laboratory
Sample No. 5.	11	mg/l	Cook Research Laboratory
Sample No. 6.	3.7	mg/l	State Public Health Laboratory
Sample No. 7.	3.7	mg/l	State Public Health Laboratory
Sample No. 8.	Sample Lost		State Public Health Laboratory

As evident from the reported values there is an extremely wide variation between the oil and grease levels for a single sample.

To further understand why these wide variations occurred, each of the laboratories have been contacted and their analytical procedures have been reviewed. The results of this review and confirming conversations with Dr. Tang Wu of the Regional Water Quality Control Board indicate that there are three acceptable procedures and two solvents which are used on oil and grease analyses. This produces six different acceptable methodologies

under which oil and grease can be analyzed. At present we have not been able to establish if there has been any research work done to compare the results using the various techniques and solvents!

During the sample splitting program which was recently completed, Cook Research Laboratory and the State Public Health Laboratory employed a Soxhlet extraction method for the analysis of oil and grease (Method 209-A, Standard Methods, 13th Edition). At the same time LFE Environmental Laboratories employed a modified semi-wet extraction method (Method 209-B, Standard Methods, 13th Edition) for the analyses of HEM. Dr. Wu of the Regional Water Quality Control Board reported that both of these methods along with a method employing a Pierson-Thomas extracture (State Water Resources Control Board Guideline for Technical Reports and Monitoring Programs) was acceptable.

The LFE Environmental Laboratory modified procedure employs the use of the direct addition of hexane to the sample to be analyzed. The Standard Method procedure calls for the sample to be filtered through diatomaceous earth and then the sample extracted in hexane. The choice of the modified procedure was made in order to accommodate the large number of samples and rapid response time which was required during the Influent Characterization Program. (Raw sewage samples often require many hours to filter through diatomaceous earth and this would have made it difficult to report values within the 48 hour deadline as requested.) Because of possible discrepancies between this procedure and the Standard Method procedure, LFE Environmental Laboratory has offered to conduct a comprehensive research project on the comparison of the two procedures. During this study samples will be run in parallel from both influent and effluent from all of the City's three treatment plants. LFE Environmental Laboratory has further agreed that they will employ method 209-A, Soxhlet Extraction Method (Standard Methods, Edition 13) for all future analyses during the San Francisco Pilot Plant Study.

To further understand the variances in the analytical procedures of oil and grease analyses, the chemists of several noted laboratories throughout the states of California and Oregon were contacted. In addition to the laboratories which were involved in the sample splitting program the Hyperian Sewage Treatment Plant Laboratory, Los Angeles; the East Bay Municipal Utility District's Laboratory in Oakland; the City's Southeast and North Point Sewage Treatment Plant Laboratories; and CH2M/HILL's laboratories in Seattle, Washington, and Corvallis, Oregon, have been contacted. Discussions on techniques and their confidence in the oil and grease procedures have been reviewed. The following paragraphs describe procedures, confidence, concerns, and general comments of the laboratory directors of these laboratories:

Dr. Yen Kwan, Director of the State Public Health Laboratory in

Berkeley, indicated that the State laboratory employed the Soxhlet Extraction Method with one extraction. Dr. Kwan said that he felt that they have had good reproducibility employing this methodology. Dr. Kwan further stated that one extraction would remove approximately 80% of the oil and grease material in most sewage samples. Dr. Kwan was particularly concerned about the sampling and sample transportation procedures. Dr. Kwan suggested that the splitting of a single sample often created more problems and more discrepancies among analyses than was desirable. His opinion was that it was almost impossible to maintain a completely homogeneous sample for aliquoting to the various laboratories. Dr. Kwan also said that only very wide mouthed bottles should be used in the transportation of samples to the laboratory. These wide mouthed bottles allow the sides of the container to be thoroughly rinsed of all adhered oil and grease. Further, Dr. Kwan said that extreme care must be taken to use only very high purity solvent during the extraction process. The State Public Health Laboratory uses hexane during extraction which they purchase in the highest quality grade possible.

Mr. Joe Nagano, Director of the Hyperian Laboratory, stated that his laboratory also employed the Soxhlet extraction method. Unlike the State laboratory, however, the Hyperian Laboratory employs two extractions with hexane during the procedure. This, he felt, gave the analyses a better reliability in removing all oil and grease. Mr. Nagano also stated concerns regarding the sampling procedures. He suggested that it was impossible to replicate a single sample with a high degree of reliability because of the problems related to mixing, coagulation, and floating of oil and grease within the sample to be aliquoted. Mr. Nagano suggested that a better test of a laboratory's procedures would be to have one sample extracted 15 or 20 times. Variability among these results would be the best possible test of reproducibility for the lab's analytical procedures. Mr. Nagano also stated his concern with the use of high purity hexane during the analytical procedure. The Hyperian Laboratory, in fact, distills all of their own hexane before use.

Mr. Roger Dolan of the East Bay Municipal Utility District Laboratory stated that their laboratory was also using the Soxhlet Extraction Method 209-A from Standard Methods. Unlike the other reported laboratories, however, the East Bay Laboratory uses freon as the extraction agent. Mr. Dolan stated that he had obtained good reliability with the use of freon and that it was desirable to hexane from a combustibility standpoint. Mr. Dolan also agreed that the sampling procedures and sample splitting techniques were probably the most important source of error in the obtaining results from the oil and grease analysis.

Mr. Dan McNulty, Superintendent of the North Point Sewage Treat-

ment Plant indicated that the North Point and Southeast Laboratories use the Soxhlet Extraction Method with one extraction. He believed that they had "fair" reproducibility in replicate studies. The Southeast Laboratory had analyzed the levels of oil and grease on the days prior to and after the sample splitting study by CH2M/HILL. Their findings were greater than 28 and 29 mg/l HEM respectively.

Mr. Larry Well, manager of the CH2M/HILL Laboratory in Corvallis, Oregon, reported that the CH2M/HILL laboratories also used the Soxhlet Extraction Technique. In addition to the concerns voiced by the other laboratory directors, Mr. Well pointed out that the operation of the extraction apparatus can also relate to the reliability of the test. The number of cycles per hour of hexane through the extraction thimble and the total time of extraction are two variables which must be watched closely to obtain replicate results. Oil and grease analyses report a wide variety of compounds; the extraction of which is highly dependent upon the particular composition of the HEM's to be analyzed.

The variety of the techniques and solvents, as well as the general concerns voiced from the various laboratories points out the difficulties in the testing procedure. In fact, Standard Methods states "the method is entirely empirical and duplicate results can be obtained only by strict adherence to all details. By definition any material recovered is called grease and any filterable organic soluble substances such as elemental sulfur and certain organic dyes will be extracted as grease." To resolve as much as possible these problems, CH2M/HILL will standardize all sampling and storage procedures. In addition, only Standard Method 209-A (Soxhlet Extraction Method) employing hexane with one extraction will be used during the remainder of the Pilot Plant Study. Strict adherance to this procedure for all samples and laboratories will be closely monitored. Hopefully these precautions will minimize any future oil and grease anomolies.

It is obvious from the foregoing that the grease and oil test is a highly empirical procedure whose results will continue to be of questionable value. It would certainly be desireable to discuss the validity of this test with the regulatory agencies before the results of the test are considered as a basis for ruling out one or more of the candidate treatment processes.

ak

SENSITIVITIES AND METHODS

CONSTITUENT		MINIMUM DETECTABLE CONCENTRATION	MINIMUM LIMIT	METHOD
METALS ug/L				
01105	ALUMINUM (AL)	10.0	20.0	AAS
01097	ANTIMONY (SB)	25.0	30.0	AAS
01002	ARSENIC (AS)	1.0	1.0	SM 104A
01007	BARIUM (BA)	10.0	10.0	AAS
01012	BERYLIUM (BE)	1.0	95.0	AAS
01017	BISMUTH (BI)	NA	NA	NA
01022	BORON (B)	20.0	60.0	SM 107B
01027	CADMIUM (CD)	1.0	1.0	AAS
00916	CALCIUM (CA)*	0.1*	9.0*	AAS
01034	CHROMIUM (CR)	1.0	1.0	AAS
01037	COBALT (CO)	5.0	7.0	AAS
01042	COPPER (CU)	5.0	25.0	AAS
00720	CYANIDE (CN)*	0.01*	0.01*	SM 207C
01045	IRON (FE)	5.0	10.0	AAS
01051	LEAD (B)	5.0	6.0	AAS
00927	MAGNESIUM (MG)*	0.01*	6.5*	AAS
01055	MANGANESE (MN)	5.0	8.0	AAS
71900	MERCURY (HG)	1.0	1.0	FAAS
01062	MOLYBDENUM (MO)	5.0	5.0	AAS
01067	NICKEL (NI)	2.5	3.0	AAS
01070	PHOSPHORUS (P)	NA	NA	NA
00937	POTASSIUM (K)*	NA	NA	NA
01147	SELENIUM (SE)	1.0	7.0	SM 150A
01142	SILICON (SI)	NA	NA	NA
01077	SILVER (AG)	1.0	1.0	AAS
00929	SODIUM (NA)*	0.1*	5.5*	AAS
01082	STRONTIUM (SR)	100.0	380.0	AAS
01059	THALLIUM (TL)	NA	NA	NA
01102	TIN (SN)	2.5	2.5	AAS
01152	TITANIUM (TI)	4.0	4.0	H_2O_2-Col. (NSM)
01087	VANADIUM (V)	10.0	14.0	AAS
01092	ZINC (ZN)	1.0	10.0	AAS

NA = Not Applicable
NSM = No Standard Method

CONSTITUENT		MINIMUM DETECTABLE CONCENTRATION	MINIMUM LIMIT	METHOD
Metals (cont'd)				
01162	ZIRCONIUM (ZR)	NA	NA	NA
71910	GOLD (AU)	NA	NA	NA
22703	URANIUM (U)	NA	NA	NA
01132	LITHIUM (LI)	10.0	5000.0	AAS
01154	TUNGSTEN (W)	NA	NA	NA
01032	CHROMIUM-6 (CR-6)	5.0	5.0	SM 117A
01047	IRON-2 (FE-2)	30.0		SM 124A
CHEMICAL Mg/l				
00435	ACIDITY	NA	NA	NA
00110	ALKALINITY	1.0	30.0	SM 102
00310	BOD-5	1.0	1.5	SM 219
00320	BOD-U	NA	NA	NA
71871	BROMIDE (BR)	0.1	0.14	SIE
00405	CO_2	NA	NA	NA
00940	CHLORIDE (CL)	1.0	6.0	SIE
00335	COD	9.0	9.0	SM 220
00300	D.O.	0.1	2.0	D.O. Meter
00951	FLUORIDE (FL)	0.1	0.38	SIE-SM 121B
71865	IODIDE (I)	0.01	0.016	SIE
70351	OIL-GREASE	1.0	5.0	SM 209A
00400	PH	NA	NA	pH meter
32730	PHENOL	0.001	0.001	SM 222C
00945	SO_4	1	12	SM 156C
00740	SO_3	0.05		SM 158
00745	$S^{=}$	0.1	0.1	SM 228A
38260	Surfactants	NA	NA	NA
00900	Hardness	1.	48.	SM 122B
00680	TOC	1.	?	TOC analyzer
	Sulfur	1.	?	Oxidation & turbidity

NA - Not Applicable

CONSTITUENT		MINIMUM DETECTABLE CONCENTRATION	MINIMUM LIMIT	METHOD
NUTRIENTS Mg/l				
00610	NH_3-N	0.01	0.01	SIE
00620	NO_3	0.01	0.01	SM 213C
00615	NO_2	0.001	0.002	SM 134
00605	Org.-N	0.1	0.18	SIE diff. (SM-135)
00600	N	0.1	5.0	SIE
00660	Ortho-PO_4	0.01	0.01	SM 223E
00650	Tot-PO_4	0.1	2.0	SM 223C + E
RADIOACTIVE pC/l				
01501	Alpha	(Note 2)	0.38	SM
03501	Beta	"	1.50	SM
09501	Ra 226	NA	NA	NA
13501	Sr 90	NA	NA	NA
PHYSICAL Mg/l				
00547	Float	0.1	0.1	SM 224F
00546	Setlb.	NA	NA	NA
00530	T. Susp.	NA	NA	NA
00076	Turb.	NA	NA	NA
00080	Color	NA	NA	NA
00095	Cond.	NA	NA	NA
00085	Odor	NA	NA	NA
00515	T.D.S.	NA	NA	NA
00500	T.S.	NA	NA	NA
00505	T.V.S.	NA	NA	NA
00535	V.S.S.	NA	NA	NA
00010	Temp.	NA	NA	NA

NA = Not Applicable

CONSTITUENT		MINIMUM DETECTABLE CONCENTRATION	MINIMUM LIMIT	METHOD
BIOASSAYS				
61400	TLM-24	NA	NA	SM 231
61401	TLM-48			
61402	TLM-96			
61403	%-24			
61404	%-48			
61405	%-96			
61406	Tox. U.			
CHLORO-HYDRO C ppb				
39782	Lindane	0.001	0.03	Note 1
39420	Hept.-E	0.001	0.02	
39365	DDE	0.001	0.07	
39360	DDD	0.001	0.089	
39370	DDT	0.001	0.068	
39380	Dieldrin	0.001	0.07	
74052	T.C.H.C.	0.01	0.42	
39330	Aldrin	0.001	17.	
39350	Chlord.	0.001	3.	
39390	Endrin	0.001	1.	
39410	Heptaclr	0.001	18.	
39480	Methclr	0.001	35.	
39400	Toxapn	0.001	5.	
39540	Org.-P	0.01	100.	
39760	Carb	0.01	-	
39730	2-4-D	0.01	-	
39516	P.C.B.	0.01	-	

* Report as Mg/l

NA = Not Applicable

Note 1: Same procedures as indicated in our letter of June 13, 1973.

Note 2: Standard Methods procedure provides variable detection limit as a function of solids content.

NOTES ON PROCEDURES

1. The sulfide and Fe^{+2} determinations will be made promptly upon arrival. along with other unstable constituents. It should be noted, however, that these two determinations may provide misleading information. Standard methods requires immediate analysis or stabilization at the time of sampling.

2. Tests have been made to determine the effect of pre-distillation on phenol and cyanide determinations. This treatment is suggested to eliminate interferences and convert, if necessary, complex cyanides into readable form. Various types of water were spiked with varying concentrations of phenol and cyanides. Unspiked samples were also run with and without distillation. At the low levels of phenol and cyanide found in S.F. waste waters, the slight loss of material always occurring with distillations often prevented detection of spikes in the lowest range. Unspiked samples in all cases yielded approximately the same values if corrections were made to compensate for slight distillation losses and if the samples were not in the lowest range.

   We have tentatively determined, therefore, that the distillations prevent achievement of the lower limits we require and that interferences do not seem to cause inaccurate results if the distillations are not employed. Further tests are currently being made to obtain more conclusive results.

3. Titanium is being analyzed colorimetrically to achieve a sensitivity of 0.004 mg/l without interference problems. A copy of the procedure is enclosed. Reference is made to this method in Sandell's Colorimetric Metal Analysis. We have carefully tested the method and found no problem with interference or quantitative recovery.

4. Total sulfur is being analyzed using an oxidation to SO_4, concentration, and SO_4 determination quantitatively by turbidimetry. The method is currently being studied to determine its reliability.

5. Ammonia, total nitrogen, bromide, iodide, chloride and fluoride will be determined using specific ion electrodes. Any interference problems have been taken care of in pretreatments and a comparison of this method with other methods showed good agreement.

6. In standard method #135, it states that organic nitrogen can be determined by difference if total nitrogen and ammonia nitrogen are determined individually. We will use this procedure.

7. Magnesium and calcium will be determined on the AA following 1-1 addition of Lanthanum HCl solution. All metals except manganese, molybdenum, thallium, strontium and lithium will be determined on the AA following CaO collection and concentration. Tracer studies and spiked samples proved this to be a high yield pretreatment method which minimizes interferences.

APPENDIX D-2

RICHMOND-SUNSET SEDIMENTATION BASIN FLOW MEASUREMENT

APPENDIX D-2

RICHMOND-SUNSET SEDIMENTATION BASIN FLOW MEASUREMENT

No device existed at Richmond-Sunset to measure the flow through a single sedimentation tank. In order to determine the amount of flow through the controlled tank, such a device was fabricated. The flow measuring device consisted of a measured shaft with which the depth of the flow at the launder brink could be determined. This is shown as y_b in the Figure D-2-1. The device as constructed is pictured in Figure D-2-2.

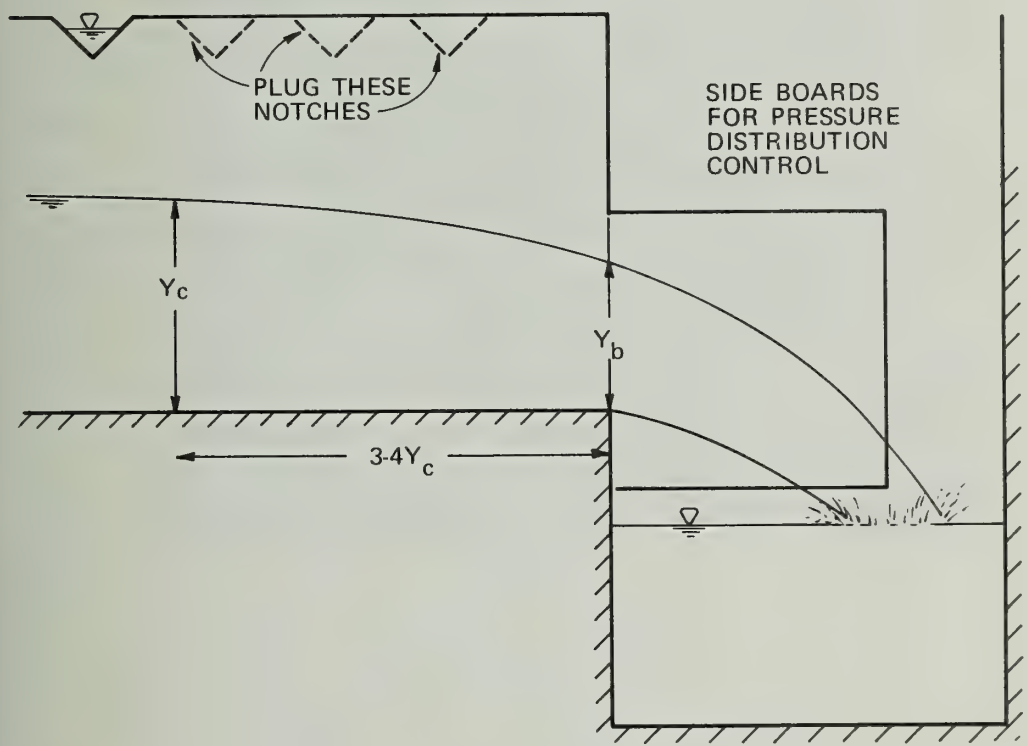

FIGURE D-2-1

The depth of the flow at the launder brink is related to the flow in the following equation:

$$Q = B \quad g \quad \frac{y_b}{0.715}^3$$

Q = flow rate, in cubic feet per second
B = channel width, (1.5 feet)
g = 32.2 feet per second
y_b = depth at the brink, in feet

Since there are four launders in each tank, it was assumed that the flow through the tank would equal four times the flow computed with the equation for one launder. This device was also calibrated to insure fairly accurate results.

For calibration purposes, the inlet gate valves to all five tanks were opened as much as possible. Through visual observation, the flow was noted to be approximately equal in each tank. Therefore, the flow that was indicated by the device for the control basin was approximately equal to the total flow registered by the plant flow meter divided by five. After 3 days of data from 24-hour operation, a calibration curve was plotted. (Figure D-2-3). The calibration was quite consistent. The calibration factor shown on Figure D-2-3 was used to adjust the computed control basin overflow rate.

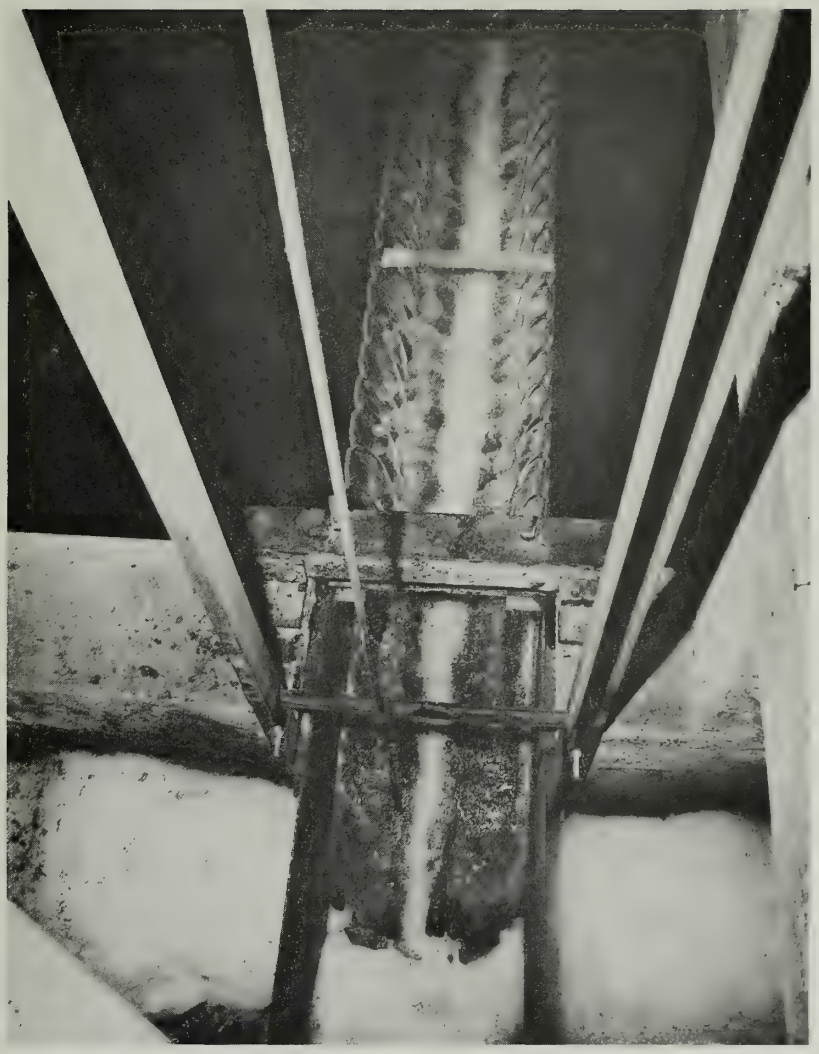

FIGURE D-2-2

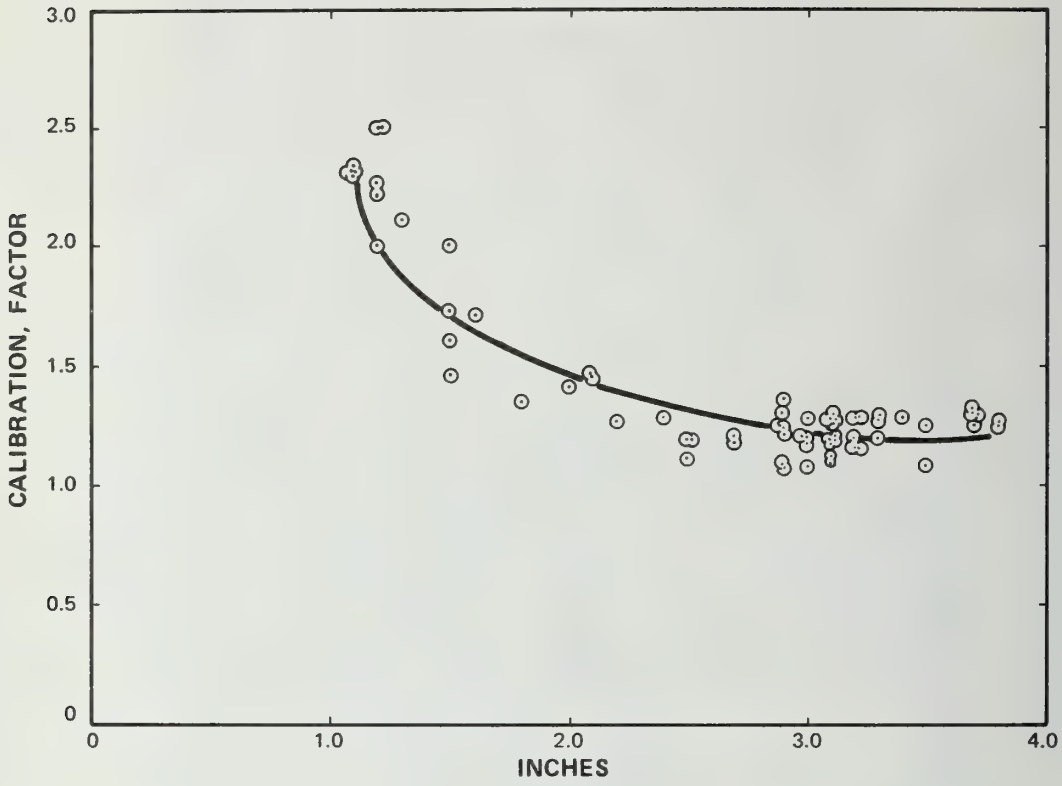

FIGURE D-2-3

CORRECTION CURVE
RICHMOND-SUNSET FLOWS

APPENDIX E

APPENDIX E

DATA RECORDING PROCEDURES

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APPENDIX E

DATA RECORDING PROCEDURES

GENERAL

As a consequence of the influent characterization program, bench scale studies, and the pilot plant program, over 50,000 individual data points were generated. These data represented the results of raw influent, liquid stream, and sludge constituent analysis; pilot plant process operational data; and special study information, such as bench scale testing programs. The large amount of data and the short period of time over which the studies were conducted required that an efficient, comprehensive data management program be developed.

Data recording procedures for the San Francisco study employed a combination of standardized report forms, manual data reduction, computer storage and organization, programmed data evaluation and interpretation, and staff review.

DATA REPORT FORMS

Table E-1 is a copy of the data report form which was used during the San Francisco pilot plant study. The report form consisted of a three part (white, yellow, pink) N.C.R. (National Cash Register Company) contact paper document. All constituent analyses and bench scale tests which were performed during the pilot plant study are included on each report form. Constituent testing is grouped on the report form according to the type of analyses to be performed, and an identification number is assigned to each constituent measurement. The lines following each abbreviated constituent are to be used to report actual data.

The Bench Studies section of the data report form, shown on

TABLE E-1

SAN FRANCISCO PILOT PLANT STUDY

NO._____

METALS ug/l	CHEMICAL Mg/l	PHYSICAL Mg/l	IDENTIFICATION
01105 Al	00435 Acdy	00547 Float	DOSAGE
01097 Sb	00410 Alk	00546 Setlb.	I01 A
01002 As	00310 BOD-5	00530 T. Susp.	I02 B
01007 Ba	00320 BOD-U	00076 Turb.	I03 C
01012 Be	71871 Br	00080 Color	00059 Flow
01017 Bi	00405 CO_2	00095 Cond.	I05 A
01022 B	00940 Cl	00085 Odor	I06 B
01027 Cd	00335 COD	00515 T.D.S.	I07 C
00916 Ca*	00300 D.O.	00500 T.S.	I10 SVI
01034 Cr	00951 Fl	00505 T.V.S.	I11 Avail. CaO
01037 Co	71865 I	00535 V.S.S.	I12 Filt. R
01042 Cu	70351 Oil-G	00010 Temp.	I13 Thickener
00720 CN*	00400 pH	BIOASSAYS	
01045 Fe	32730 Phenol		
01051 Pb	00945 SO_4	61400 TLM-24	
00927 Mg*	00740 SO_3	61401 TLM-48	
01055 Mn	00745 $S^=$	61402 TLM-96	BENCH STUDIES → CHECK
71900 Hg	38260 Surf.	61403 %-24	
01062 Mo	00900 Hard	61404 %-48	
01067 Ni	00680 TOC	61405 %-96	
01070 P		61406 Tox U.	COAGULATION
00937 K*		CHLORO-HYDRO C ppb	ALUM
01147 Se			HI LIME
01142 Si		39782 Lindane	LO LIME
01077 Ag	NUTRIENTS Mg/l	39420 Hept-E	HI FeCl
00929 Na*		39365 DDE	LO FeCl
01082 Sr	00610 NH_3-N	39360 DDD	POLYMER
01059 Tl	00620 NO_3	39370 DDT	
01102 Sn	00615 NO_2	39380 Dieldrin	
01152 Ti	00605 Org-N	74052 T.C.H.C.	CARBON ISOTHERM
01087 V	00600 N	39330 Aldrin	
01092 Zn	00660 Ortho-PO_4	39350 Chlord.	CENTRIFUGE
01162 Zr	00650 Tot-PO_4	39390 Endrin	
71910 Au		39410 Heptaclr	SLUDGE YIELD
22703 U		39480 Methclr	
01132 Li		39400 Toxapn	MICRO. EXAM.
01154 W		39540 Org.-P	
01032 Cr-6	RADIOACTIVE pC/l	39760 Carb	
01047 Fe-2	01501 Alpha	39730 2-4-D	
	03501 Beta	39516 P.C.B.	
	09501 Ra 226		
*Report as Mg/l	13501 Sr 90		

COMMENTS:_____

ALIQUOT*_____ OF_____ LABORATORY_____ BY_____

RUN*_____ IDENT.*_____ COMPOSITE TIME*_____ TO_____ MISC.*_____

			DATE			TIME		
NO	STP	LOCATION	MON	DAY	YR	HR	MIN	TYPE

COLLECTOR_____ CH2M HILL

the right hand margin of the data form, was used only when bench scale studies were to be conducted. To immediately draw attention to the desired processing of a sample, the check box was marked. Within this segment, the lines following the particular bench study were used to indicate the range of the bench scale study which was desired. (For example, the range of dosage upon which high lime coagulation studies were to be conducted would be indicated on the line following "hi lime").

Sample identification is accomplished by two means from the data report form. In the upper right hand corner a consecutive number is printed on each form. This number is unique to each sample and is assigned chronologically. Reference to the "NCR number" will then allow quick identification of each sample.

The printed series of boxes across the bottom of the NCR form also are used for sample identification. A coded letter(s) or number(s) is used to define (1) the pilot plant program and process, (2) station location, (3) date and time of sample collection, and (4) type of sample. This fourteen digit code remains with the sample information during all data processing, storing, and interpretation.

The remaining information printed on the data report forms is used to (1) deliver the sample to the correct laboratory, (2) identify the collector and analyzer of the sample, and (3) provide additional information as to the nature of the sampling location and duration of collection. A "comments" section is also included for the inclusion of observed anomalies during the collection, transportation or analysis of the sample.

SAMPLE MANAGEMENT

Samples obtained from the pilot plant were of two basic types:

grab samples and composite samples. Grab samples were normally obtained manually from the process to be studied. After collection, the grab samples were stored under refrigeration until delivery to the analytical laboratories.

Composite samples were normally collected over a 24-hour period. Automated sample pumps delivered a pulse flow to two, 5-gallon (19 liter) polyethylene refrigerated containers. During the collection period, a sample of 9 to 10 gallons (34 to 38 liters) were obtained. At certain locations near the head end of the pilot plant it was observed that the sample pumps could not accurately deliver representative samples to the composite containers. At these locations rags and hair would collect on the sampler and act as a filter. After the first 5 days of the North Point-Southeast test run, Stations 33, 34, 1, 3, and 4 were sampled each hour by hand and the individual grab samples were composited.

All samples were refrigerated until delivery to the analytical laboratory - which always occurred within eight hours of the sample collection. Upon receipt of the samples, the analytical laboratory would freeze approximately one liter of the sample. Freezing insured sufficient volume for possible reruns and additional testing if required. All indicated analyses were then conducted on the remaining unfrozen sample.

DATA REPORT PROCEDURES

All constituent and bench scale data generated from the pilot plant study were processed by means of the data report forms. All samples obtained from the pilot plant were accompanied by the 3-page NCR forms. Strict adherence to this procedure made it possible to keep track of all generated data.

Once each sample was properly labeled, pilot plant engineers or chemists would circle the constituents which were to be analyzed on the sample (or indicate bench scale studies, if

appropriate). The sample along with the yellow and pink copies of the data report form would then be sent to the appropriate laboratory. The white (top) copy would be sent to CH2M HILL'S offices at 360 Pine Street and would be placed in a "Preliminary File." Frequently, when all the required sample data and analyses were known prior to collection, the data report forms would be filled out completely at the CH2M HILL offices and only the pink and yellow copies would be sent to the pilot plant for attachment to the proper samples.

Within 48 hours of sample delivery each laboratory would return the yellow NCR copy, with handwritten results of the completed analyses to CH2M HILL'S office. The yellow form was then matched to its appropriate white counterpart. The combined sheets would then be transferred to an "In Progress" file. Each laboratory was also provided with a tablet of supplemental yellow forms. As additional analyses were completed, the blank yellow forms were manually filled out and transmitted to CH2M HILL. By comparison of the original white NCR form with subsequent yellow forms, it was possible to keep track of the outstanding analyses and sample location.

As yellow handwritten NCR forms were received at CH2M HILL, data were transmitted by teletype to the central computer for storage. After all analyses for a particular sample had been completed and checked, the analytical laboratory would type a final white copy of the results. Upon receipt at CH2M HILL the final white copy would be compared with the handwritten white and yellow NCR forms to check completion of the test results and agreement between the reported values. If all forms agreed, they would then be transferred to a final "Completed" file. The pink NCR form was retained by each analytical laboratory for its records.

Those data forms which requested bench studies were sent to the operational laboratory at the pilot plant site. At the operation laboratory forms were printed for each of the bench study procedures. Upon completion of the specific bench scale studies, the form reporting the bench scale results was attached to the yellow copy of the data form and returned to the 360 Pine Street offices of CH2M HILL. These bench scale studies would then go into a separate "Bench Scale Study" file. Bench scale study results were then incorporated into the computer data storage program.

Operational data obtained from the pilot plant, such as process flows, chemical dosages, and sludge volumes, were recorded on individual "station sheets". These forms were attached to clipboards and located at each sampling point on the pilot plant. The "station sheets" were collected every 24 hours at midnight and sent to the CH2M HILL office. Examples of the "station sheets" used for recording data at the filters are shown in the pilot plant operation appendix.

Upon receipt of the daily operational data three composite operational report forms were composed. The first composite report, the Solid Stream Data Input Report, was used to record all sludge volumes and flows obtained from the pilot plant (Table E-2). The second form, Liquid Stream Data Input Report, records flow, chemical dosage, turbidity, pH, recycle and length of run for each process of the pilot plant (Table E-3). The third composite operational report form (Table E-4) was used to compile data from the filter and carbon column daily operation. The total hours of operation, flow rate, total flow, head loss, end turbidity, and backwash total are recorded.

While the data report procedures for constituent, bench scale and operational data were complex, they allowed for a close control of the pilot plant information which was necessary for a successful project. In some cases, data for the completion

TABLE E-2

SAN FRANCISCO PILOT PLANT
SOLID STREAM DATA INPUT REPORT

TYPE [ ] DATE [MO.][DAY][YR] TIME [HR][MIN.]

PPP	LTN	FLOW 106
	42	
	43	
	44	
	45	
	46	
	47	
	48	
	49	
	50	
	51	
	52	
	53	
	54	
	55	
	56	
	57	
	58	
	59	
	60	
	61	
	62	
	63	
	64	
	65	
	66	
	67	
	68	
	69	
	70	
	71	

TABLE E-3

SAN FRANCISCO PILOT PLANT
LIQUID STREAM DATA INPUT REPORT

TYPE ☐ DATE MO DAY YR ☐☐ ☐☐ ☐☐ TIME HR MIN ☐☐ ☐☐

PPP	LTN	PROCESS FLOW GPM FLOW 108	DOSAGE mg/L HI LIM 121	LO LIM 122	HI FE 123	LO FE 124	HI ALM 125	LO ALM 126	A-POLY 127	N-POLY 128	CHLRN 129	$NaNO_3$ 130	TURBIDITY JTU AVG 00078	MAX 141	MIN 142	pH MEAN 00400	MAX 146	MIN 148	PROCESS RECYCLE % RCYL 107	PROCESS RUN HOURS RUN 161
	01																			
	02																			
	03																			
	04																			
	05																			
	06																			
	07																			
	08																			
	09																			
	10																			
	11																			
	12																			
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	30																			
	31																			
	32																			
	33																			
	34																			
	35																			
	36																			
	37																			
	38																			
	39																			

COMMENTS _____ BY _____

TABLE E- 4

FILTER AND CARBON COLUMN RUNS

REPORT DATE_____ BY_____

CARBON COLUMNS AND FILTERS									
SEWAGE TREATMENT PLANT	LOCATION	END DATE AND TIME	TYPE	HOURS 152	RATE 153	QT 154	H_L 155	TURB. END 000F6	BHT 156

of the composite operational reports were directly obtained from the "station sheets". For other parameters, such as dosage and total flows, the data were calculated.

The completed daily operational composite reports served two functions: (1) they allowed pilot plant engineers to quickly review the previous day's operation and correct any problems, and (2) they are organized to aid in the transmittal of data to the central computer storage facility.

DATA MANAGEMENT SYSTEM

The San Francisco pilot plant study data management system was developed to provide an automated interpretation and review of the large amount of data produced during the project. In addition, the use of computer storage and standardized data sorting made it possible for direct transfer of the accumulated information to the City or the regulatory agencies. Finally, data can be easily transferred to cards or tape for long-term storage requiring little space.

All constituent and process data collected from the pilot plant were filed according to a three or five digit code. This code was obtained from the E.P.A. STORET System for most constituents analyzed. Some constituent and process data did not have assigned STORET code numbers and it was necessary for a special identifier to be assigned. All three digit codes were developed especially for parameters not included in the EPA STORET System. The three digit codes all begin with an (I) which indicated an Identification Number.

The STORET Code numbers and Identification numbers were printed on all data report and composite operational data input forms. These "name codes" allowed for quick identification of each parameter and enabled data to be directly input to the computer system from the handwritten forms. A complete list of the "name codes" (STORET numbers + Identification numbers) and their descriptions are shown in Table E-5.

TABLE E-5
NAME CØDES
AND
DESCRIPTIØNS
IN
FILE ERC01

CØDE	DESCRIPTIØNS
I01	PRØCESS DØSAGE A MG/L
I02	PRØCESS DØSAGE B MG/L
I03	PRØCESS DØSAGE C MG/L
I05	INFLUENT RECYCLE PERCENT
I06	PRØCESS FLØW (GPM)
I07	PRØCESS RECYCLE PERCENT
I08	PRØCESS FLØW MGD
I10	SLUDGE VØLUME INDEX VØL ML/1 GRAM
I11	AVAILABLE CALCIUM ØXIDE MG/L
I12	FILTER LEAF TEST CLØTH NUMBER
I13	SLUDGE THICKENING TEST ML/L/HØUR
I21	HIGH LIME DØSAGE MG/L CA(ØH)2
I22	LØW LIME DØSAGE MG/L CA(ØH)2
I23	FERRIC CHLØRIDE DØSAGE MG/L
I24	LØW FERRIC DØSAGE MG/L
I25	HIGH ALUM DØSAGE MG/L
I26	LØW ALUM DØSAGE MG/L
I27	ANIØNIC PØLYMER DØSAGE MG/L
I28	NØNIØNIC PØLYMER DØSAGE MG/L
I29	CHLØRINE DØSAGE MG/L
I30	SØDIUM NITRATE DØSAGE MG/L
I31	SØDIUM HYDRØXIDE MG/L
I41	MAXIMUM TURBIDITY FTU HØURLY GRAB SAMPLE
I42	MINIMUM TURBIDITY FTU HØURLY GRAB SAMPLE
I45	MAXIMUM DAILY PH (PH UNITS)
I46	MINIMUM DAILY PH (PH UNITS)
I48	AVERAGE SETTLEABLE SØLIDS ML/L/HØUR
I49	MAXIMUM SETTLEABLE SØLIDS ML/L/HØUR
I50	MINIMUM SETTLEABLE SØLIDS ML/L/HØUR
I51	NUMBER ØF PRØCESS RUNS EACH DAY
I52	PRØCESS RUN LENGTH (HØURS)
I53	AVERAGE PRØCESS RUN RATE (GAL/FT2/MIN)
I54	TØTAL PRØCESS FLØW
I55	FINAL HEAD LØSS (FILTER INCHES CC PSI)
I56	TØTAL PRØCESS BACKWASH (GAL)
00010	TEMPERATURE DEGREES CENTIGRADE
00059	INFLUENT FLØW MGD
00076	AVERAGE TURBIDITY FTU HØURLY GRAB SAMPLE
00080	CØLØR PLATINUM-CØBALT UNITS
00085	ØDØR THRESHØLD NUMBER
00095	CØNDUCTIVITY MICRØMHØS AT 25 DEGREES C
00300	DISSØLVED ØXYGEN MG/L
00310	5 DAY BØD MG/L
00311	DISSØLVED 5 DAY BØD MG/L
00320	ULTIMATE BØD MG/L
00335	CHEMICAL ØXYGEN DEMAND MG/L

TABLE E-5 (continued)

11/30/73 NAME CØDES PAGE 8

AND

DESCRIPTIØNS

IN

FILE ERC01

CØDE	DESCRIPTIØNS
00341	DISSØLVED CHEMICAL ØXYGEN DEMAND MG/L
00400	MEDIAN DAILY PH (PH UNITS)
00405	CARBØN DIØXIDE MG/L
00410	ALKALINITY MG/L
00435	ACIDITY MG/L
00500	TØTAL SØLIDS MG/L
00505	TØTAL VØLATILE SØLIDS MG/L
00515	TØTAL DISSØLVED SØLIDS MG/L
00530	TØTAL SUSPENDED SØLIDS MG/L
00535	VØLATILE SUSPENDED SØLIDS MG/L
00546	SETTLEABLE SØLIDS MG/L
00547	FLØATABLES MG/L
00600	TØTAL NITRØGEN MG/L
00605	ØRGANIC NITRØGEN MG/L
00610	AMMØNIA-NITRØGEN MG/L
00615	NITRITE-NITRØGEN MG/L
00620	NITRATE-NITRØGEN MG/L
00650	TØTAL PHØSPHATE MG/L
00660	ØRTHØ PHØSPHATE MG/L
00680	TØTAL ØRGANIC CARBØN MG/L
00720	CYANIDE MG/L
00740	SULFATE MG/L
00745	SULFIDE MG/L
00900	HARDNESS MG/L
00916	CALCIUM MG/L
00927	MAGNESIUM MG/L
00929	SØDIUM MG/L
00937	PØTASSIUM MG/L
00940	CHLØRIDE MG/L
00945	SULFATE MG/L
00951	FLØURIDE MG/L
01002	ARSENIC MICRØ-G/L
01007	BARIUM MICRØ-G/L
01012	BERYLLIUM MICRØ-G/L
01017	BISMUTH MICRØ-G/L
01022	BØRØN MICRØ-G/L
01027	CADMIUM MICRØ-G/L
01032	HEXAVALENT CHRØMIUM MICRØ-G/L
01034	TØTAL CHRØMIUM MICRØ-G/L
01037	CØBALT MICRØ-G/L
01042	CØPPER MICRØ-G/L
01045	TØTAL IRØN MICRØ-G/L
01047	FERRØUS IRØN MICRØ-G/L
01051	LEAD MICRØ-G/L
01055	MANGANESE MICRØ-G/L
01059	THALLIUM MICRØ-G/L

TABLE E-5 (continued)

NAME CØDES AND DESCRIPTIØNS IN FILE ERC01

CØDE	DESCRIPTIØNS
01062	MØLYBDENUM MICRØ-G/L
01067	NICKEL MICRØ-G/L
01070	PHØSPHØRUS MICRØ-G/L
01077	SILVER MICRØ-G/L
01082	STRØNTIUM MICRØ-G/L
01087	VANADIUM MICRØ-G/L
01092	ZINC MICRØ-G/L
01097	ANTIMØNY MICRØ-G/L
01102	TIN MICRØ-G/L
01105	ALUMINUM MICRØ-G/L
01132	LITHIUM MICRØ-G/L
01142	SILICØN MICRØ-G/L
01147	SELENIUM MICRØ-G/L
01152	TITANIUM MICRØ-G/L
01154	TUNGSTEN MICRØ-G/L
01162	ZIRCØNIUM MICRØ-G/L
01501	GRØSS ALPHA PC/L
03501	GRØSS BETA PC/L
09501	RADIUM 226 PC/L
13501	STRØNTUIM 90 PC/L
22703	URANIUM MICRØ-G/L
32730	PHENØL MG/L
38260	SURFACTANTS MG/L
39330	ALDRIN PPB
39350	CHLØRDANE PPB
39360	DDD PPB
39365	DDE PPB
39370	DDT PPB
39380	DIELDRIN PPB
39390	ENDRIN PPB
39400	TØXAPHENE PPB
39410	HEPTACHLØR PPB
39420	HEPTACHLØR EPØXIDE PPB
39430	METHØXYCHLØR PPB
39516	PØLYCHLØRINATED BIPHENYLS PPB
39540	(MALATHIØN) + PARATHIØN PPB
39730	2-4-D PPB
39760	CARBAMATES (SILVEX) PPB
39782	LINDANE PPB
61400	24 HØUR-MEDIAN TØLERANCE LIMIT (PERCENT)
61401	48 HØUR-MEDIAN TØLERANCE LIMIT (PERCENT)
61402	96 HØUR-MEDIAN TØLERANCE LIMIT (PERCENT)
61403	24 HØUR-PERCENT SURVIVAL UNDILUTED WASTE
61404	48 HØUR-PERCENT SURVIVAL UNDILUTED WASTE
61405	96 HØUR-PERCENT SURVIVAL UNDILUTED WASTE
61406	96 HØUR-TØXICITY UNITS

TABLE E-5 (continued)

11/30/73 NAME CØDES AND DESCRIPTIØNS IN FILE ERC01 PAGE 10

CØDE	DESCRIPTIØNS
70351	ØIL & GREASE MG/L
71865	IØDIDE MG/L
71871	BRØMIDE MG/L
71900	MERCURY MICRØ-G/L
71910	GØLD MICRØ-G/L
74052	TØTAL CHLØRINATED HYDRØCARBØNS PPB
80116	SØLUBLE CHEMICAL ØXYGEN DEMAND MG/L

1

F7725.60 $ 6.55

In addition to the standardized "name codes", data from the pilot plant was indexed under "major and minor keys", data and time of collection and "type codes." Provision for these labels was printed on each data report form in 14 horizontally aligned boxes. The "major key" was designated by STP (or PPP) on each report form. The "major key" was used to identify the type of raw sewage and pilot plant process involved for the collected data. A complete listing of the available "major keys" is shown in Table E-6.

The "minor key" designator is represented by two boxes on each report form. The "minor key" defines the station location from which the sample was obtained. Minor keys between 01 and 39 have been assigned to liquid stream sampling points; numbers 41 through 72 have been designated for sludge samples; and numbers 81 through 93 have been reserved for sampling at the Richmond-Sunset Water Pollution Control Plant. Number 99 has been used for sample analyses not directly connected with pilot plant or full scale plant processes. A complete listing of the available "minor keys" is shown in Table E-7.

The sample collection date and time were also listed for each data point. This information was recorded on each report form in eight preprinted boxes. This information was filed by month, day, and year, using only two digits for the year of collection. Time was recorded using a 24 hour clock. This sequence of date and time labeling has been adopted to be directly compatible with similar STORET coding.

The last identifier for each sample is the "type code." This code defines the type of sample obtained. Composite samples are labeled according to the closest hourly "type code H. A complete listing of the available "type codes" is shown in Table E-8.

TABLE E-6
MAJØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERJ01'

KEY= XX

KEY= A
SØUTHEAST NØN-SPECIFIC PRØCESS

KEY= AA
RS BENCH SCALE ALUM

KEY= AB
RS BENCH SCALE FERRIC

KEY= AC
RS BENCH SCALE HI LIME

KEY= AD
RS BENCH SCALE LØ LIME

KEY= AE
NP+SE+RS BENCH SCALE ALUM

KEY= AF
NP+SE+RS BENCH SCALE FERRIC

KEY= AG
NP+SE+RS BENCH SCALE HI LIME

KEY= AH
NP+SE+RS BENCH SCALE LØ LIME

KEY= AI
NP+SE+RS+RECYCLE BENCH SCALE ALUM

KEY= AJ
NP+SE+RS+RECYCLE BENCH SCALE FERRIC

KEY= AK
NP+SE+RS+RECYCLE BENCH SCALE HI LIME

KEY= AL
NP+SE+RS+RECYCLE BENCH SCALE LØ LIME

KEY= AM
NP + SE NØN-SPECIFIC PRØCESS

KEY= AN
NP + SE CØNVENTIØNAL A.S. PRØCESS

KEY= AØ
NP + SE H.P.Ø. ACTIVATED SLUDGE PRØCESS

KEY= AP
NP + SE HIGH ALUM PRØCESS

KEY= AQ
NP + SE LØW ALUM PRØCESS

KEY= AR
NP + SE HIGH FERRIC PRØCESS

KEY= AS
NP + SE FERRIC PRØCESS

KEY= AT
NP + SE HIGH LIME PRØCESS

KEY= AU
NP + SE LØW LIME PRØCESS

KEY= AV
NP + SE DIRECT FILTRATIØN PRØCESS

KEY= AW
NP + SE H.P.Ø. - A.S. PLUS FERRIC PRØCESS

KEY= AX
NP + SE H.P.Ø. - A.S. PLUS LIME PRØCESS

KEY= AY
NP + SE H.P.Ø. - A.S. PLUS ALUM PRØCESS

KEY= AZ
NP + SE CØNVENTIØNAL A.S. PLUS FERRIC PRØCESS

KEY= B
SE CØNVENTIØNAL A.S. PRØCESS

KEY= BA
NP + SE CØNVENTIØNAL A.S. PLUS LIME PRØCESS

TABLE E-6 (continued)
MAJØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERJ01'

KEY= BB
NP + SE CØNVENTIØNAL A.S. PLUS ALUM PRØCESS

KEY= BC
NP + SE FERRIC PLUS LIME PRØCESS

KEY= BD
NP + SE ALUM PLUS LIME PRØCESS

KEY= C
SE H.P.Ø. - A.S. PRØCESS

KEY= D
SE HIGH ALUM PRØCESS

KEY= E
SE LØW ALUM PRØCESS

KEY= F
SE HIGH FERRIC PRØCESS

KEY= G
SE FERRIC PRØCESS

KEY= H
SE HIGH LIME PRØCESS

KEY= I
SE LØW LIME PRØCESS

KEY= IN
ERD01

KEY= J
SE DIRECT FILTRATIØN PRØCESS

KEY= K
SE H.P.Ø. - A.S. PLUS FERRIC PRØCESS

KEY= L
SE H.P.Ø. - A.S. PLUS LIME PRØCESS

KEY= M
SE H.P.Ø. - A.S. PLUS ALUM PRØCESS

TABLE E-6 (continued)
MAJØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERJ01'

KEY= N
SE CØNVENTIØNAL A.S. PLUS FERRIC PRØCESS

KEY= Ø
SE CØNVENTIØNAL A.S. PLUS LIME PRØCESS

KEY= P
SE CØNVENTIØNAL A.S. PLUS ALUM PRØCESS

KEY= Q
SE FERRIC PLUS LIME PRØCESS

KEY= R
SE ALUM PLUS LIME PRØCESS

KEY= RA
RICHMØND-SUNSET NØN SPECIFIC

KEY= RB
RICHMØND-SUNSET ALUM CØNTRØLLED FLØW PRØCESS

KEY= RC
RICHMØND-SUNSET ALUM UNCØNTRØLLED FLØW PRØCESS

KEY= S
SE BENCH SCALE ALUM

KEY= T
SE BENCH SCALE FERRIC

KEY= U
SE BENCH SCALE HI LIME

KEY= V
SE BENCH SCALE LØ LIME

KEY= W
NP BENCH SCALE ALUM

KEY= X
NP BENCH SCALE FERRIC

KEY= Y
NP BENCH SCALE HI LIME

TABLE E-6 (continued)
MAJØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERJ01'

KEY= Z
NP BENCH SCALE LØ LIME

KEY= ZX
CHEMICAL ANALYSIS LIME

KEY= ZY
CHEMICAL ANALYSIS ALUM

KEY= ZZ
CHEMICAL ANALYSIS FERRIC CHLØRIDE

TABLE E-7
MINØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERM01'

KEY= 0
CØMPØSITE SAMPLES

KEY= 1
1 CØMBINED RAW SEWAGE

KEY= 2
2 RECYCLE ADDED TØ RAW SEWAGE

KEY= 3
3 RAW SEWAGE PLUS RECYCLE

KEY= 4
4 PRIMARY CLARIFIER EFFLUENT - BIØLØGICAL PRØCESS

KEY= 5
5 CØNVENTIØNAL A.S EFFLUENT

KEY= 6
6 CHEMICAL FLØCULATØR EFFLUENT

KEY= 7
7 CHEMICAL CLARIFIER EFFLUENT

KEY= 8
8 FILTER EFFLUENT

KEY= 9
9 CARBØN CØLUMN EFFLUENT

KEY= 10
10 H.P.Ø. - A.S. EFFLUENT

KEY= 11
11 FILTER EFFLUENT

KEY= 12
12 CARBØN CØLUMN EFFLUENT

KEY= 13
13 CHEMICAL FLØCULATØR EFFLUENT

KEY= 14
14 CHEMICAL CLARIFIER EFFLUENT

TABLE E-7 (continued)
MINØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERM01'

KEY= 15
15 FILTER EFFLUENT

KEY= 16
16 CARBØN CØLUMN EFFLUENT

KEY= 17
17 LIME FLØCULATØR EFFLUENT

KEY= 18
18 LIME CLARIFIER EFFLUENT

KEY= 19
19 FIRST STAGE LIME RECARB EFFLUENT

KEY= 20
20 RECARBØNATIØN CLARIFIER EFFLUENT

KEY= 21
21 SECØND STAGE LIME RECARB EFFLUENT

KEY= 22
22 FILTER EFFLUENT

KEY= 23
23 CARBØN CØLUMN EFFLUENT

KEY= 24
24 LIME THICKENER EFFLUENT TØ RECYCLE STØRAGE

KEY= 25
25 CØMBINED LIME CENTRIFUGE AND SCRUBBER EFFLUENT

KEY= 26
26 LIME RECYCLE STØRAGE EFFLUENT

KEY= 27
27 CHEMICAL FLØCULATØR EFFLUENT

KEY= 28
28 CHEMICAL - CLARIFIER EFFLUENT

KEY= 29
29 FILTER EFFLUENT

TABLE E-7 (continued)
MINØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERM01'

KEY= 30
30 CARBØN CØLUMN EFFLUENT

KEY= 31
31 CØNVENTIØNAL A.S MIXED LIQUØR

KEY= 32
32 H.P.Ø. - A.S. MIXED LIQUØR

KEY= 33
33 SØUTHEAST RAW SEWAGE

KEY= 34
34 NØRTHPØINT RAW SEWAGE

KEY= 35
CARBØN CØLUMN 9

KEY= 36
CARBØN CØLUMN 12

KEY= 37
CARBØN CØLUMN 16

KEY= 38
CARBØN CØLUMN 23

KEY= 39
CARBØN CØLUMN 30

KEY= 41
41 PRIMARY CLARIFIER SCUM

KEY= 42
42 PRIMARY CLARIFIER SLUDGE

KEY= 43
43 CØNVENTIØNAL A.S WASTE SLUDGE

KEY= 44
44 CØNVENTIØNAL A.S RECYCLE SLUDGE

KEY= 45
45 CHEMICAL CLARIFIER RECYCLE SLUDGE

TABLE E-7 (continued)
MINØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERM01'

KEY= 46
46 CHEMICAL CLARIFIER WASTE SLUDGE

KEY= 47
47 FILTER BACKWASH

KEY= 48
48 CARBØN BACKWASH

KEY= 49
49 TØTAL H.P.Ø. - A.S. SLUDGE

KEY= 50
50 H.P.Ø. - A.S. WASTE SLUDGE

KEY= 51
51 H.P.Ø. - A.S. RECYCLE SLUDGE

KEY= 52
52 FILTER BACKWASH

KEY= 53
53 CARBØN BACKWASH

KEY= 54
54 CHEMICAL CLARIFIER SLUDGE RECYCLE

KEY= 55
55 CHEMICAL CLARIFIER WASTE SLUDGE

KEY= 56
56 FILTER BACKWASH

KEY= 57
57 CARBØN BACKWASH

KEY= 58
58 LIME CLARIFIER SCUM

KEY= 59
59 TØTAL LIME CLARIFIER SLUDGE

KEY= 60
60 LIME CLARIFIER RECYCLE SLUDGE

TABLE E-7 (continued)
MINØR TITLE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERM01'

KEY= 61
61 LIME CLARIFIER WASTE SLUDGE

KEY= 62
62 LIME RECARB SLUDGE

KEY= 63
63 LIME THICKENER SLUDGE TØ BATCH ØPERATIØNS

KEY= 64
64 LIME CENTRIFUGE SLUDGE

KEY= 65
65 LIME RECAL FURNACE SLUDGE

KEY= 66
66 FILTER BACKWASH

KEY= 67
67 CARBØN BACKWASH

KEY= 68
68 CHEMICAL CLARIFIER RECYCLE SLUDGE

KEY= 69
69 CHEMICAL CLARIFIER WASTE SLUDGE

KEY= 70
70 FILTER BACKWASH

KEY= 71
71 CARBØN BACKWASH

KEY= 72
72 SEDIMENTATIØN BASIN SLUDGE

KEY= 81
81 RICHMØND-SUNSET RAW INFLUENT

KEY= 82
82 SEDIMENTATIØN BASIN EFFLUENT

KEY= 83
83 3 FØØT FILTER EFFLUENT

KEY= 84
84 CARBØN CØLUMN EFFLUENT

KEY= 85
85 SEDIMENTATIØN BASIN EFFLUENT

KEY= 86
86 3 FØØT FILTER EFFLUENT

KEY= 87
87 7 FØØT FILTER FILTER EFFLUENT

KEY= 90
90 FILTER BACKWASH

KEY= 91
91 CARBØN BACKWASH

KEY= 92
92 FILTER BACKWASH

KEY= 93
93 FILTER BACKWASH

KEY= 99
NØN APPLICABLE SAMPLING PØINT

TABLE E-8
TYPE CØDE KEYS
AND
DESCRIPTIØNS
FØR
FILE 'ERT01'

KEY= A
GRAB SAMPLE

KEY= B
3 HØUR CØMPØSITE

KEY= C
6 HØUR CØMPØSITE

KEY= D
12 HØUR CØMPØSITE

KEY= E
18 HØUR CØMPØSITE

KEY= F
24 HØUR CØMPØSITE

KEY= G
2 DAY CØMPØSITE

KEY= H
3 DAY CØMPØSITE

KEY= I
4 DAY CØMPØSITE

KEY= J
5 DAY CØMPØSITE

KEY= K
6 DAY CØMPØSITE

KEY= L
7 DAY CØMPØSITE

DATA MANAGEMENT PROGRAMS

A total listing of all commands available to the data management system is given in Table E-9. The following paragraphs describe the major command programs used during the pilot plant data interpretation.

1. Data Listing Command.

   The data listing command (LIST) outputs all data stored in the data files. Data is listed by STORET code without regard to sampling location. This command is used for a total printing of all data without organization.

2. Data Review Command.

   The review command (RVEW) allows the user to summarize all data for a given constituent at one or more sampling points. This program provides the user with the capability of examining all or part of the test data relating to a specific constituent and only include the relevant processes by inputting the code RVEW, the appropriate pilot plant location, and sample type (composite or grab) along with the constituent STORET number followed spaces and appropriate sampling locations and finally followed by an end command (EXIT).
   The RVEW command also prints out the median (middle) value and 10th percentile value for each data set. The median value is the value in ordered set of constituent results below and above which there is an equal number of values or which is the arithmetic mean of the two middle values if there is no one middle number. The 10th percentile number is that value for which 10 percent of the data is larger and 90 percent of the data is smaller. The

TABLE E-9
SAN FRANCISCO PILOT PLANT DATA MANAGEMENT PROGRAMS

* * * * * * * * * SUMMARY ØF CØMMANDS * * * * * * * * *

FILE	DEFINES FILE FØR SUBSEQUENT ØPERATIØNS
PAGE	ALLØWS RESET ØF PAGE NUMBER FØR ØUTPUT
DATS	DEFINES UPPER AND LØWER DATE BØUNDARIES FØR ØUTPUT
TIMS	DEFINES UPPER AND LØWER TIME BØUNDARIES FØR ØUTPUT
LIMT	SETS DATA LIMITS FØR DATA DISPLAY ØR CØMPUTING
VØLM	VØIDS DATA LIMITS - ESTABLISHED BY LIMT
VØDT	VØIDS DATE LIMITS - ESTABLISHED BY DATS
VØTM	VØIDS TIME LIMITS - ESTABLISHED BY TIMS
INIT	DESTRØYS FILE CØNTENTS ØF ALL ØR SELECTED FILES
PURG	PURGES DUPLICATE ØR ERRØNEØUS DATA VALUES LEAVING LAST ENTERED
RDFX	READ AND STØRE FIXED FØRMAT DATA - CARD INPUT ØNLY
RDFR	FREE FØRMAT DATA ENTRY TYPE I - CØNSTITUENT REPØRT FØRM
VØFR	VØID RECØRDS - DATA FØRMAT FREE FØRM TYPE I
RDFZ	FREE FØRMAT DATA ENTRY TYPE II - FØR PHYSICAL DATA
VØFZ	VØID RECØRDS - DATA FØRMAT - FREE FØRM TYPE II
RDMJ	READ AND STØRE MAJØR LØCATIØN CØDES AND TITLES
RDMN	READ AND STØRE MINØR LØCATIØN CØDES AND TITLES
RDTP	READ AND STØRE TYPE CØDE S AND DESCRIPTIØNS
RDCD	READ AND STØRE NAME CØDES AND DESCRIPTIØNS
LIST	LISTS ALL DATA IN DATA FILE - NØT RECØMMENDED FØR TELETYPE
LSDM	LISTS ALL DATA FØR SPECIFIC MAJØR CØDE ØR CØDES
LSDL	LIST ALL DATA FØR SPECIFIC MINØR ØR SAMPLING PØINT LØCATIØNS
LDPL	LIST ALL DATA AT SPECFIC MAJØR/MINØR LØCATIØN
LCØD	LIST NAME CØDES AND THEIR DESCRIPTIØNS
LMAJ	LIST MAJØR LØCATIØN TAGS AND TITLES
LMIN	LIST MINØR LØCATIØN TAGS AND TITLES
LTYP	LIST TYPE CØDES

RVEW	LISTS DATA FØR STRING ØF MAJØR/MINØR LØCATIØNS
CMPR	CØRRELATIØN ANALYSIS ØF TWØ DATA PØINTS
PREM	PERCENT REMØVAL ØF A CØNSTITUENT ACRØSS TWØ SAMPLING PØINTS
MASS	CALCULATIØN ØF LBS ØF MASS FØR A CØNSTITUENT
CØRL	CØEFFICIENT ØF RELIABILITY CALCULATIØN
EXIT	SIGNALS END ØF RUN

* * * * * * * *

median and 10th percentile values are listed under 50 percent and 10 percent headings, respectively.

3. The Coefficient of Reliability Command.

The coefficient of reliability command (CORL) provides the user with the ability to examine removal characteristics of several processes as measured by the coefficient of reliability. By inputting (CORL) the pilot plant location, the constituent standard for which the data is being evaluated and the appropriate STORET codes - followed by an end command (EXIT) - a coefficient of reliability printout is obtained. Data are displayed in a tabular form on a single page or several, if required. The values from which the coefficient is computed are outputted as well as the coefficient.

The coefficient of reliability expression used during the automated data interpretation base be developed from the formula and definitions shown in Appendix C. In addition to the coefficient of reliability, the CORL output includes the standard value of comparison, the displacement from the standard and the range of the middle 80% of the data which is used during the calculation of the coefficient of reliability.

4. Percent Removal Command.

The PREM, or percent removal command, provides a means of tabulating the percent removal across one or more processes. This program is initiated by typing in the code PREM, the sewage treatment plant,

followed by the STORET number and series of sampling locations. One or more sample locations can be inputted. The output of this program is tabular. Percent removals are based upon the differences between successive values for each sample location inputted with the data card. Percent removal is calculated with each pair as input. The final or total percent removal can also be calculated from the data values if more than two locations are specified. Total removal is calculated from the first and last sampling location stated.

APPENDIX F

METRICATION TABLE

English Unit	Multiplier	Metric Unit
acre	$\times 0.405 \rightarrow$ $\leftarrow 2.471 \times$	ha
acre-ft	$\times 1{,}233.5 \rightarrow$ $\leftarrow 8.11 \times 10^{-4} \times$	cu m
BTU	$\times 0.252 \rightarrow$ $\leftarrow 3.968 \times$	kg-cal
BTU/lb	$\times 0.555 \rightarrow$ $\leftarrow 1.80 \times$	kg-cal/kg
bu	$\times 35.24 \rightarrow$ $\leftarrow 0.0281 \times$	l
bu	$\times 0.03524 \rightarrow$ $\leftarrow 28.1 \times$	cu m
cfm	$\times 0.028 \rightarrow$ $\leftarrow 35.71 \times$	cu m/min
cfs	$\times 1.7 \rightarrow$ $\leftarrow 0.588 \times$	cu m/min
cfs/acre	$\times 4.2 \rightarrow$ $\leftarrow 0.238 \times$	cu m/min/ha
cfs/sq miles	$\times 0.657 \rightarrow$ $\leftarrow 1.522 \times$	cu m/min/sq km
cu ft	$\times 0.028 \rightarrow$ $\leftarrow 35.314 \times$	cu m
cu ft	$\times 28.32 \rightarrow$ $\leftarrow 0.0353 \times$	l
cu in.	$\times 16.39 \rightarrow$ $\leftarrow 0.061 \times$	cu cm
cu yd	$\times 0.75 \rightarrow$ $\leftarrow 1.3709 \times$	cu m
°F	$0.555\ (°F - 32) \rightarrow$ $\leftarrow 1.8\ (°C) + 32$	°C
fathom	$\times 1.8 \rightarrow$ $\leftarrow 0.555 \times$	m
ft	$\times 0.3048 \rightarrow$ $\leftarrow 3.28 \times$	m
ft-c	$\times 10.764 \rightarrow$ $\leftarrow 0.929 \times$	lumen/sq m
gal	$\times 3.785 \rightarrow$ $\leftarrow 0.264 \times$	l
gpd/acre	$\times 0.00935 \rightarrow$ $\leftarrow 106.9 \times$	cu m/day/ha
gpd/ft	$\times 0.0124 \rightarrow$ $\leftarrow 80.65 \times$	cu m/day/m
gpd/sq ft	$\times 0.0408 \rightarrow$ $\leftarrow 24.51 \times$	cu m/day/sq m
gpm	$\times 0.0631 \rightarrow$ $\leftarrow 15.85 \times$	l/sec
gpm/sq ft	$\times 40.7 \rightarrow$ $\leftarrow 0.0245 \times$	l/min/sq m
hp	$\times 0.7454 \rightarrow$ $\leftarrow 1.341 \times$	kw
in.	$\times 2.54 \rightarrow$ $\leftarrow 0.3937 \times$	cm
lb	$\times 0.454 \rightarrow$ $\leftarrow 2.205 \times$	kg

METRICATION TABLE

English Unit	Multiplier	Metric Unit
lb/day/acre-ft	$\times 3.68 \rightarrow$ $\leftarrow 0.2717 \times$	g/day/cu m
lb/1,000 cu ft	$\times 16.0 \rightarrow$ $\leftarrow 0.0625 \times$	g/cu m
lb/day/acre	$\times 0.112 \rightarrow$ $\leftarrow 8.93 \times$	g/day/sq m
lb/day/cu ft	$\times 16 \rightarrow$ $\leftarrow 0.0625 \times$	kg/day/cu m
lb/day/sq ft	$\times 4{,}880 \rightarrow$ $\leftarrow 2.05 \times 10^{-4} \times$	g/day/sq m
lb/ft	$\times 1.49 \rightarrow$ $\leftarrow 0.671 \times$	kg/m
lb/mil gal	$\times 0.92 \rightarrow$ $\leftarrow 8.333 \times$	g/cu m
mgd	$\times 3{,}785 \rightarrow$ $\leftarrow 2.64 \times 10^{-4} \times$	cu m/day
mgd/acre	$\times 9{,}365 \rightarrow$ $\leftarrow 1.068 \times 10^{-4} \times$	cu m/day/ha
mile	$\times 1.61 \rightarrow$ $\leftarrow 0.621 \times$	km
ppb	$\times 10^{-3} \rightarrow$ $\leftarrow 1{,}000 \times$	mg/l
ppm	equals	mg/l
pcf	$\times 16.02 \rightarrow$ $\leftarrow 0.0625 \times$	kg/cu m
psf	$\times 4.88 \rightarrow$ $\leftarrow 0.2048 \times$	kg/sq m
psi	$\times 0.0703 \rightarrow$ $\leftarrow 14.22 \times$	kg/sq cm
sq ft	$\times 0.0929 \rightarrow$ $\leftarrow 10.76 \times$	sq m
sq ft/cu ft	$\times 3.29 \rightarrow$ $\leftarrow 0.304 \times$	sq m/cu m
sq in.	$\times 6.452 \rightarrow$ $\leftarrow 0.1550 \times$	sq cm
sq miles	$\times 2.590 \rightarrow$ $\leftarrow 0.3861 \times$	sq km
tons (short)	$\times 907 \rightarrow$ $\leftarrow 1.102 \times 10^{-3} \times$	kg
tons (short)	$\times 0.907 \rightarrow$ $\leftarrow 1.102 \times$	metric tons

APPENDIX F

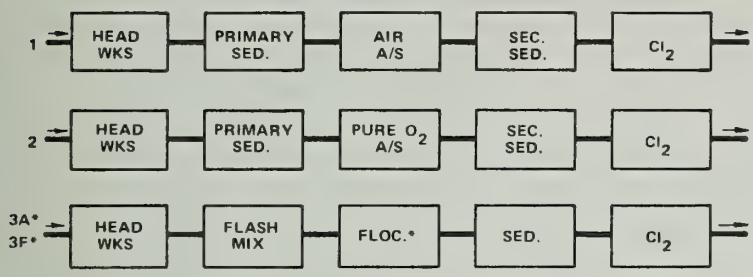
COST ESTIMATE DETAILS
NORTH POINT – SOUTHEAST PLANT

PROCESS TRAINS	PAGE
STATE OCEAN DISCHARGE STANDARDS	
Train A-1 (Air Activated Sludge)	A-1-1 to A-1-9
Train A-2 (HPO Activated Sludge)	A-2-1 to A-2-9
Train A-3-A (Alum PP/C	A-3A-1 to A-3A-7
Train A-3-F (Ferric PP/C)	A-3F-1 to A-3F-7
EPA DISCHARGE STANDARDS	
Train B-1 (Air Activated Sludge)	Same as Train A-1
Train B-2 (HPO Activated Sludge)	Same as Train A-2
Train B-3-A (Alum TP/C)	B-3A-1 to B-3A-9
Train B-3-F (Ferric TP/C)	B-3F-1 to B-3F-9
Train B-4-A (Alum TP/C with Lime Treatment)	B-4A-1 to B-4A-12
Train B-4-F (Ferric TP/C with Lime Treatment)	B-4F-1 to B-4F-12
RWQCB TENTATIVE BAY DISCHARGE STANDARDS	
Train C-1 (Air Activated Sludge with Filtration)	C-1-1 to C-1-9
Train C-2 (HPO Activated Sludge with Filtration)	C-2-1 to C-2-9
Train C-3-A (Alum TP/C)	Same as Train B-3A
Train C-3-F (Ferric TP/C)	Same as Train B-3F
Train C-4-A (Alum TP/C with Lime Treatment)	Same as Train B-4A
Train C-4-F (Ferric TP/C with Lime Treatment)	Same as Train B-4F

RICHMOND-SUNSET PLANT

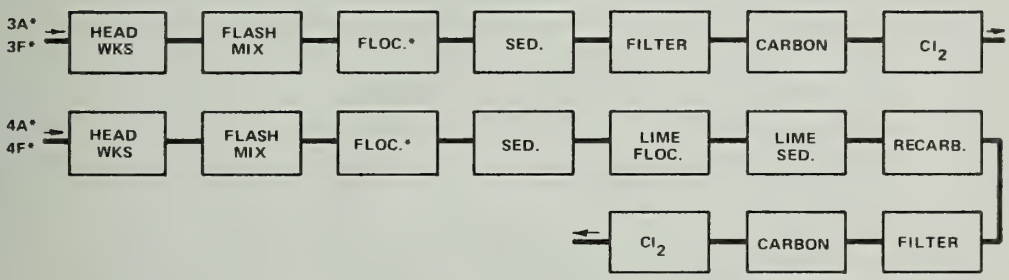
PROCESS TRAIN	PAGE
STATE OCEAN DISCHARGE STANDARDS	
RS-A-2 (HPO Activated Sludge)	RS-A-2-1 to RS-A-2
RS-A-2A (Alum PP/C)	
RS-A-2C (Cationic PP/C)	
EPA DISCHARGE STANDARDS	
RS-B-2 (HPO Activated Sludge)	Same as RS-A-2
RWQCB DISCHARGE STANDARDS	
(Not Applicable)	

A. TRAINS TO MEET STATE OCEAN DISCHARGE STANDARDS



B. TRAINS TO MEET EPA STANDARDS

1. SAME AS A-1 ABOVE
2. SAME AS A-2 ABOVE



C. TRAINS TO MEET RWQCB TENTATIVE BAY DISCHARGE STANDARDS

1. SAME AS A-1 PLUS FILTER
2. SAME AS A-2 PLUS FILTER

3A AND F SAME AS B-3A AND F

4A AND F SAME AS B-4A AND F

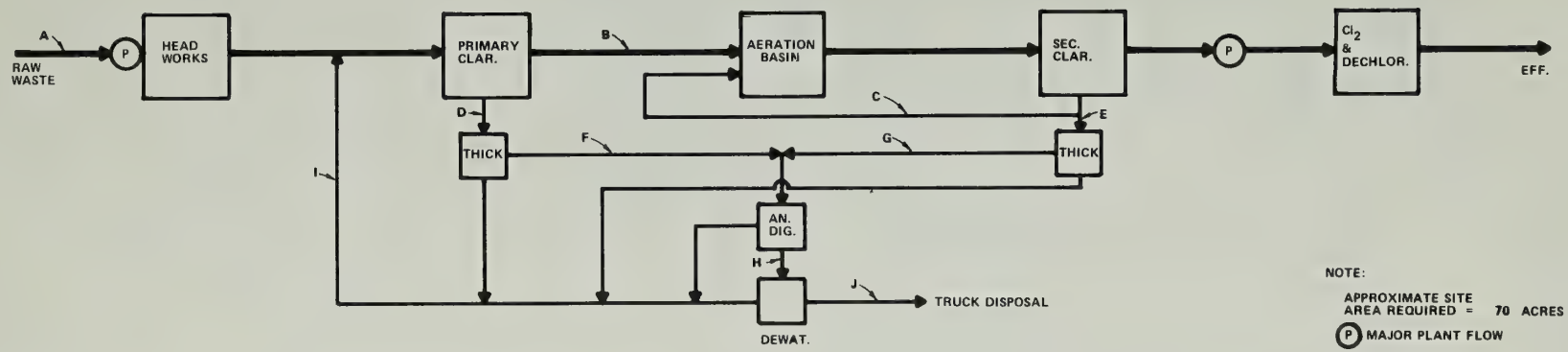
*ALUM OR FERRIC CHLORIDE

NORTH POINT – SOUTHEAST
PROCESS TRAINS SELECTED FOR
AN ECONOMIC EVALUATION

TRAINS A-1 AND B-1

AIR ACTIVATED SLUDGE

TREATMENT TRAINS A-1 AND B-1 // AIR ACTIVATED SLUDGE FOR OCEAN & EPA STANDARDS



NOTE:

APPROXIMATE SITE AREA REQUIRED = 70 ACRES

(P) MAJOR PLANT FLOW

A → POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B	C	D	E	F	G	H	I	J
Ave. Daily Flow Rate (mgd)	100	–	30	–		.19	.21	–	2.0	–
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180		72	–	–	.29	.38	–	3.5	–
Ave. Daily BOD_5 (1000 lbs./day)	200	129	–		–		–		–	
Peak 24hr. BOD_5 (1000 lbs./day)	346	225	–		–		–		–	–
Ave. Suspended Solids (1000 lbs./day)	167		–	81	71	81	71	115	29	86
Peak 24hr. Suspended Solids (1000 lbs./day)	524			123	127	123	127		–	–
Percent Solids	–		–	3.0	0.5	5.0	4.0	5.0	–	22

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN A-1 AND B-1

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$6,530	$ 548	$ 5,530	$ 5,210	$10,740
Primary Treatment	9,220	310	7,810	2,950	10,760
Air Activated Sludge	31,260	1,453	26,480	13,810	40,289
Post Chlorination and Dechlorination	1,990	287	1,690	2,730	4,420
Solids Disposal	8,060	1,287	6,830	12,200	19,030
SUBTOTAL	$57,060	$3,890	$48,340	$36,900	$85,240
Ancillary Systems and Facilities[5]	6,530	382	5,530	3,630	9,160
TOTAL	$63,590	$4,270	$53,870	$40,530	$94,400

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TABLE 2

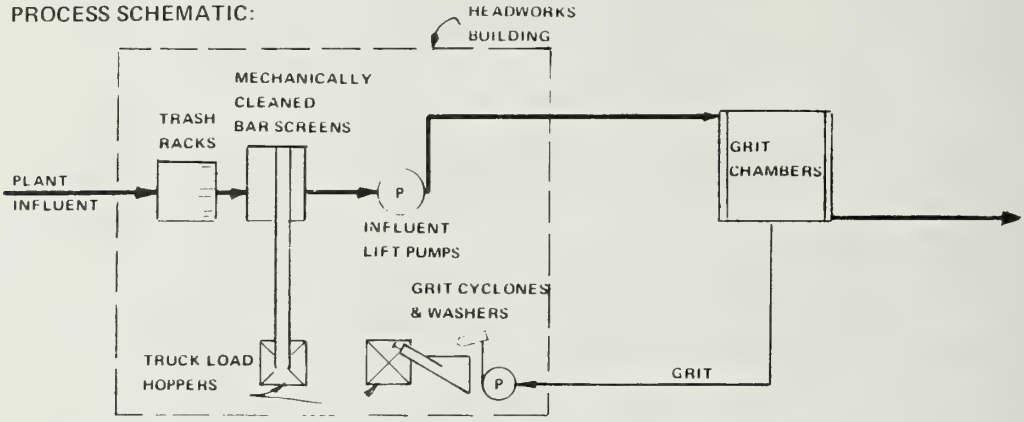
NORTH POINT – SOUTHEAST PLANT
AIR ACTIVATED SLUDGE
PROCESS DESIGN PARAMETERS

PARAMETER	DESIGN CAPACITY	MAXIMUM CAPACITY
AERATION BASINS		
Flow, mgd-Q	100	180
Recycle, %	30	40
Primary effluent BOD_5 mg/l		
Average	155	–
Maximum	270	175
MLSS, mg/l	3500	3000
MLVSS, mg/l	2800	2400
F/M lb BOD_5/lb MLVSS/day		
Average	0.17	–
Maximum	0.3	0.4
Detention Time		
at Q, hrs	7.7	4.3
at Q + R, hrs	6.0	–
Oxygen required for 90% BOD_R @ 1.2 lbs O_2/lbs BOD_R		
Average, lbs O_2/hr	5820	–
Maximum, lbs O_2/hr	10130	–
CLARIFIERS		
Hydraulic Loading		
at Q, gpd/sq. ft.	430	770
at Q + R, gpd/sq. ft.	560	–
Solids Loading		
at Q + R, lbs/ft^2/day	15	–

TREATMENT TRAIN: [A-1], A-2, A-3, B-1, B-2, B-3, B-4, C-1, C-2, C-3, C-4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

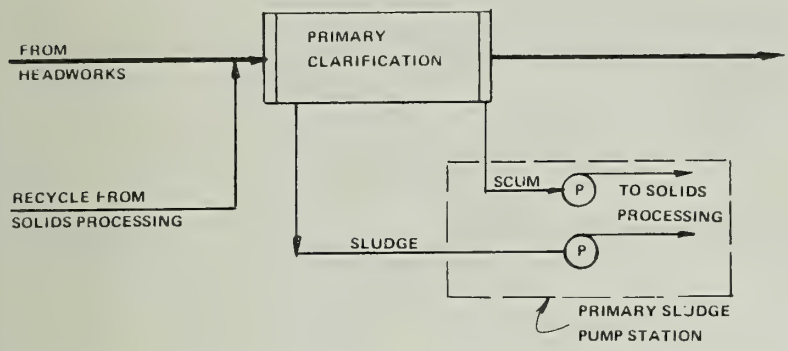
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: [A-1], A-2, B-1, B-2

UNIT PROCESS: PRIMARY TREATMENT

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Primary Clarifiers: 1,000 gpd/ft^2 at 180 MGD

NO. PROCESS UNITS: 20 Clarifiers

REDUNDANCY @ 100 MGD: 1 Clarifier

INDIVIDUAL PROCESS UNIT SIZE: 300'x30'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 230
MAINTENANCE LABOR	13
POWER	30
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	310
CAPITAL COST	9,220

PRESENT VALUE OF COSTS:

O, M & R	2,946
CAPITAL	7,811
TOTAL	$10,757

FIGURE 3

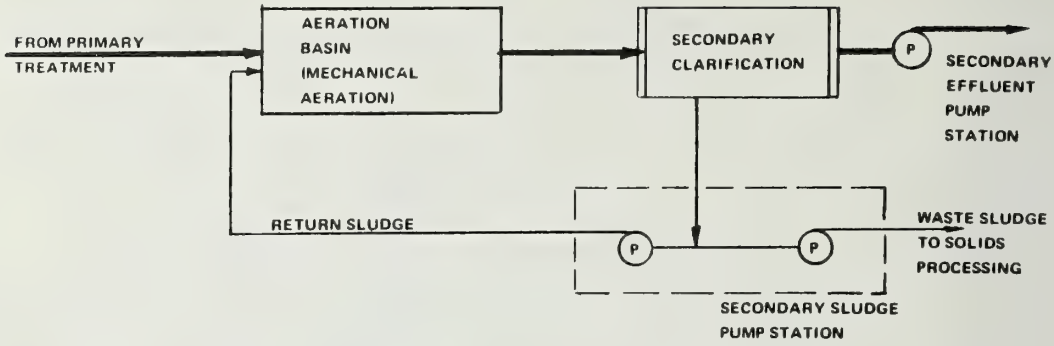
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A-1, B-1

UNIT PROCESS: AIR ACTIVATED SLUDGE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: See next page

NO. PROCESS UNITS: 18 Aeration Basins and Clarifiers 4-75 HP Turbine Mechanical Mixers per Basin = 5,400 HP Total

REDUNDANCY @ 100 MGD: 1 Basin

INDIVIDUAL PROCESS UNIT SIZE: Aeration Basin 116'x116'x18' SWD each Clarifier 325'x40'x15' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 332
MAINTENANCE LABOR	103
POWER	843
FUEL	–
CHEMICALS	–
PARTS	175
MISCELLANEOUS	
TOTAL ANNUAL O & M	1,453
CAPITAL COST	31,260

PRESENT VALUE OF COSTS:

O, M & R	13,806
CAPITAL	26,483
TOTAL	$40,289

FIGURE 4

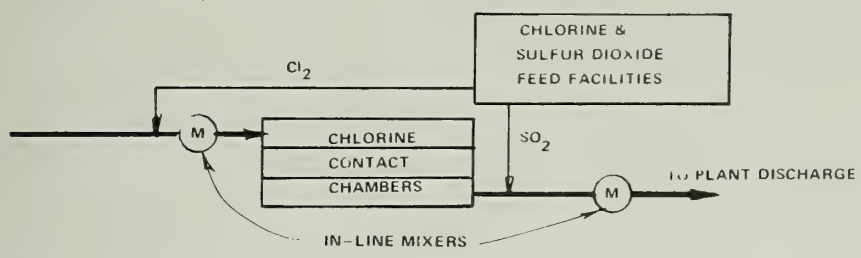
PROCESS UNIT DATA
COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: [A-1], A-2, A-3, B-1, B-2, B-3, B-4, C-1, C-2, C-3, C-4

UNIT PROCESS: POST CHLORINATION AND DE-CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 5

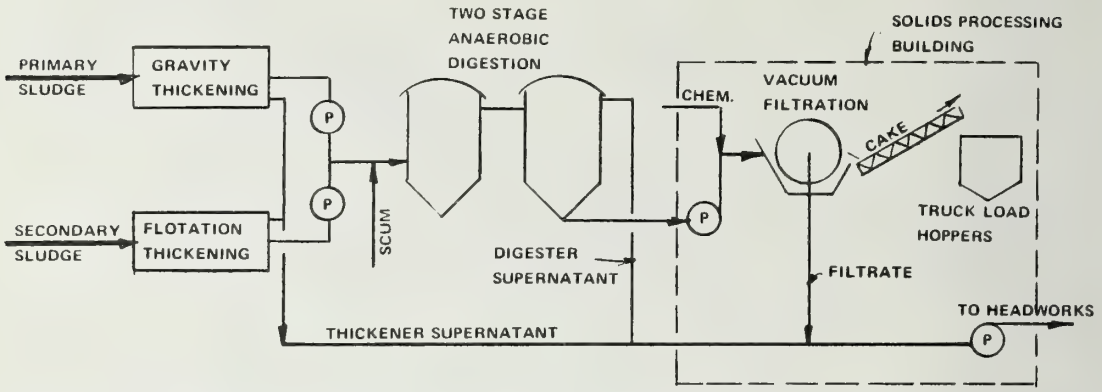
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A-1, B-1,

UNIT PROCESS: ORGANICS SOLIDS THICKENING, DIGESTION & DEWATERING

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Gravity Thickening – 20 #/ft^2/day at 180 MGD Flotation Thickening – 48 #/ft^2/day at 180 MGD and Digesters – 0.1 #VSS/ft^3/day and 20 day detention at 100 MGD; Vacuum Filters 96#/ft^2/day at 100 MGD

NO. PROCESS UNITS: Gravity Thickening -3; Flotation Thickening -5; Digesters -5; Vacuum Filters -3

REDUNDANCY @ 100 MGD: One of each type (thickeners at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Gravity Thickening -65' ϕ (3,320 ft^2); Flotation Thickening 20'x35' (700 ft^2); Digester 100' ϕ x 35' (274,000 ft^3); Vacuum Filters 12' ϕ x 16' (605 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 337
MAINTENANCE LABOR	101
POWER	131
FUEL	–
CHEMICALS	216
PARTS	110
SLUDGE HAUL	393
TOTAL ANNUAL O & M	1,287
CAPITAL COST	8,060

PRESENT VALUE OF COSTS:

O, M & R	12,200
CAPITAL	6,830
TOTAL	$19,030

FIGURE 6

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 3

MISCELLANEOUS OPERATING COSTS

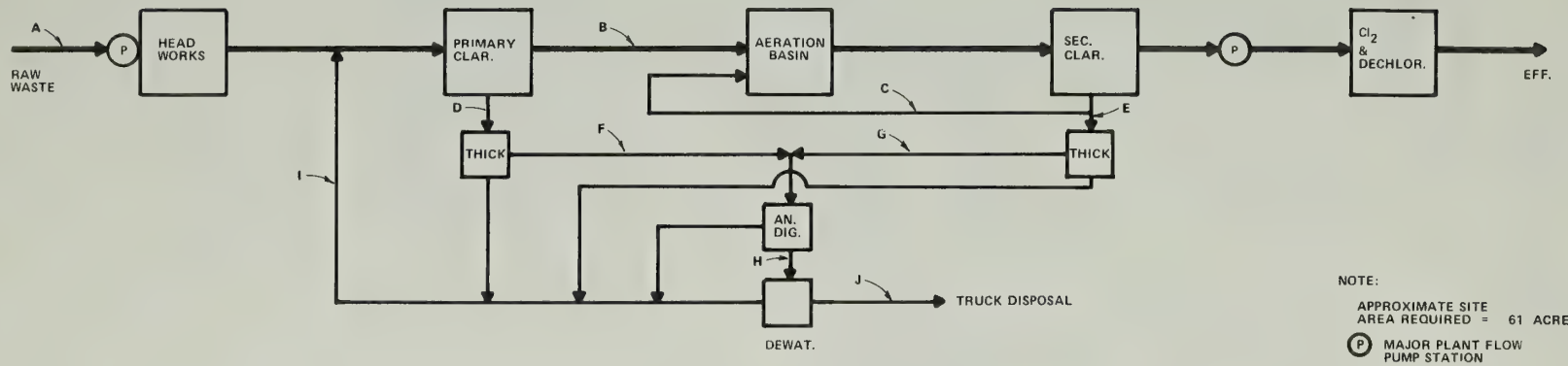
TREATMENT TRAIN: A-1

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 163
CLERICAL	66
LABORATORY	103
YARD WORK	50
TOTAL ANNUAL COST	382
PRESENT VALUE	$3,631

TRAINS A-2 AND B-2

HPO ACTIVATED SLUDGE

TREATMENT TRAINS A-2 AND B-2 HIGH PURITY OXYGEN ACTIVATED SLUDGE FOR OCEAN & EPA STANDARDS



NOTE:

APPROXIMATE SITE AREA REQUIRED = 61 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A → POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B	C	D	E	F	G	H	I	J
Ave. Daily Flow Rate (mgd)	100		30			.20	.17		.90	-
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180		60	-	-	.30	.30		1.52	-
Ave. Daily BOD_5 (1000 lbs./day)	200	129			-		-		-	-
Peak 24hr. BOD_5 (1000 lbs./day)	346	225	-	-			-	-	-	-
Ave. Suspended Solids (1000 lbs./day)	167			82	72	82	72	116	29	87
Peak 24hr. Suspended Solids (1000 lbs./day)	524			124	129	124	129	-	-	
Percent Solids				3.0	1 5	5.0	5.0	5.0	-	22

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN A-2 AND B-2

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$5,530	$ 5,210	$10,740
Primary Treatment	9,220	310	7,810	2,950	10,760
Oxygen Activated Sludge	27,190	1,170	23,030	11,100	34,130
Post Chlorination and Dechlorination	1,990	290	1,690	2,730	4,420
Solids Disposal	7,350	1,210	6,230	11,540	17,770
SUBTOTAL	$52,280	$3,530	$44,290	$33,530	$77,820
Ancillary Systems and Facilities[5]	6,000	380	5,080	3,630	8,710
TOTAL	$58,280	$3,910	$49,370	$37,160	$86,530

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TABLE 2

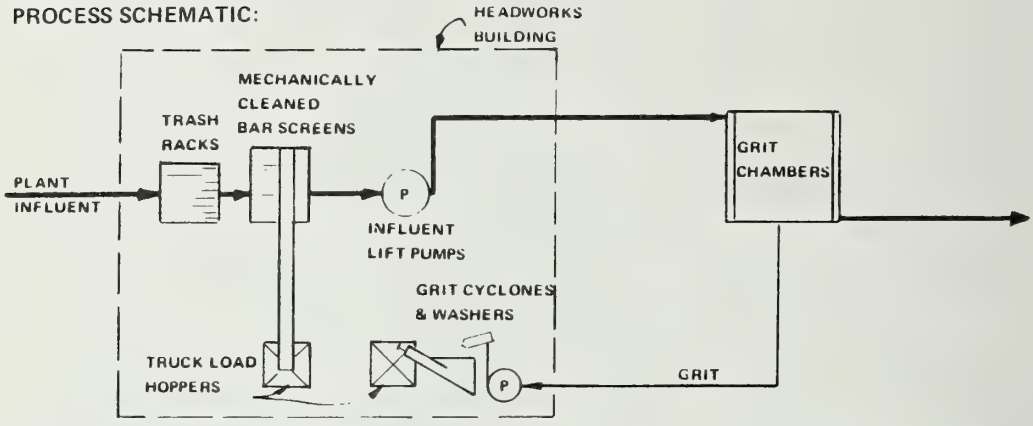
NORTH POINT – SOUTHEAST PLANT
HIGH PURITY OXYGEN ACTIVATED SLUDGE
PROCESS DESIGN PARAMETERS

PARAMETER	DESIGN CAPACITY	MAXIMUM CAPACITY
AERATION BASIN		
Flow, mgd – Q	100	180
Recirculation, %	30	40
Primary effluent BOD, mg/l		
Average	155	–
Maximum	270	175
F/M, lb BOD/lb MLVSS/day		
Average	0.35	–
Maximum	0.61	0.83
Detention Time		
at Q, hrs	2.3	1.3
at Q + R, hrs	1.8	0.93
MLSS, mg/l	5600	4800
MLVSS, mg/l	4500	3860
Average D.O., mg/l	6	3
O_2 required for 90% reduction		
lbs O_2/lb BOD_R	1.5	0.9
Oxygen generated ton/day (at 90% efficiency)		
Average	96	–
Maximum	168	118
CLARIFIER		
Hydraulic Loading		
gpd/ft^2 at Q	550	990
Solids Loading Rate		
Q + R lbs/ft^2/day	–	–
Maximum	33	55

TREATMENT TRAIN: A–1, **A–2**, A–3, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

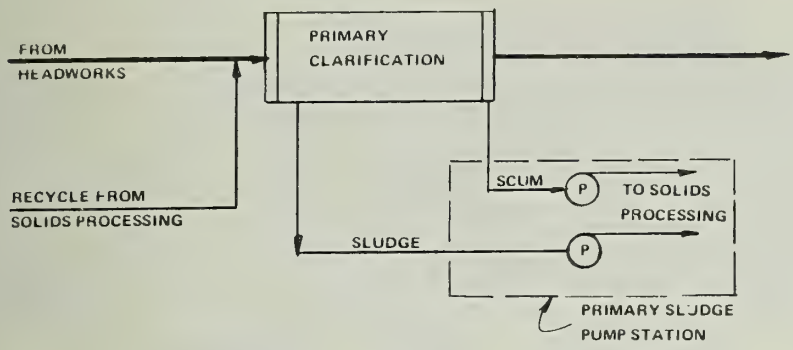
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, B–1, B–2

UNIT PROCESS: PRIMARY TREATMENT

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Primary Clarifiers: 1,000 gpd/ft^2 at 180 MGD

NO. PROCESS UNITS: 20 Clarifiers

REDUNDANCY @ 100 MGD: 1 Clarifier

INDIVIDUAL PROCESS UNIT SIZE: 300'x30'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 230
MAINTENANCE LABOR	13
POWER	30
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	310
CAPITAL COST	9,220

PRESENT VALUE OF COSTS:

O, M & R	2,946
CAPITAL	7,811
TOTAL	$10,757

FIGURE 3

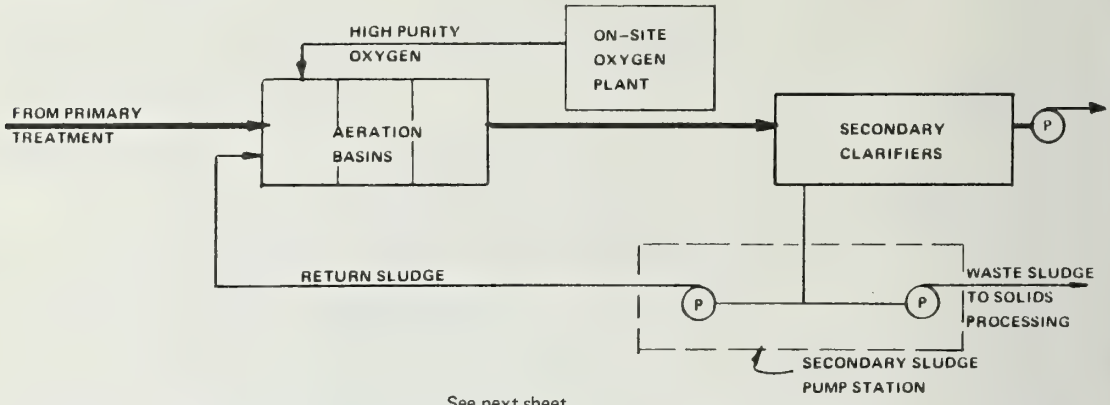
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A-2, B-2

UNIT PROCESS: HIGH PURITY OXYGEN– ACTIVATED SLUDGE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: See next sheet

NO. PROCESS UNITS: 2-81 Ton/day Cryogenic Oxygen Plants, 2-50,000 gal. Liquid O_2 Storage, Power (Average/Peak) 1870 BHP/2,750 BHP, Dissolution 1,425/2,020. Total Aeration Basin 270'x180'x27' SWD, 14 Clarifiers

REDUNDANCY @ 100 MGD: 1/6 Basin 1 Clarifier

INDIVIDUAL PROCESS UNIT SIZE: Clarifier 325'x40'x15' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 372
MAINTENANCE LABOR	118
POWER	525
FUEL	–
CHEMICALS	–
PARTS	152
MISCELLANEOUS	–
TOTAL ANNUAL O & M	1,168
CAPITAL COST	27,187

PRESENT VALUE OF COSTS:

O, M & R	11,098
CAPITAL	23,033
TOTAL	34,131

FIGURE 4

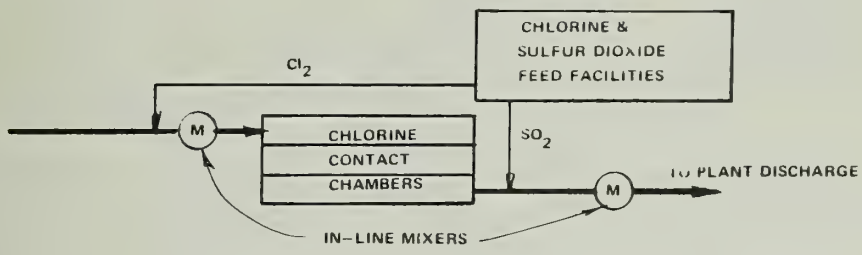
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, [A–2,] A–3, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 5

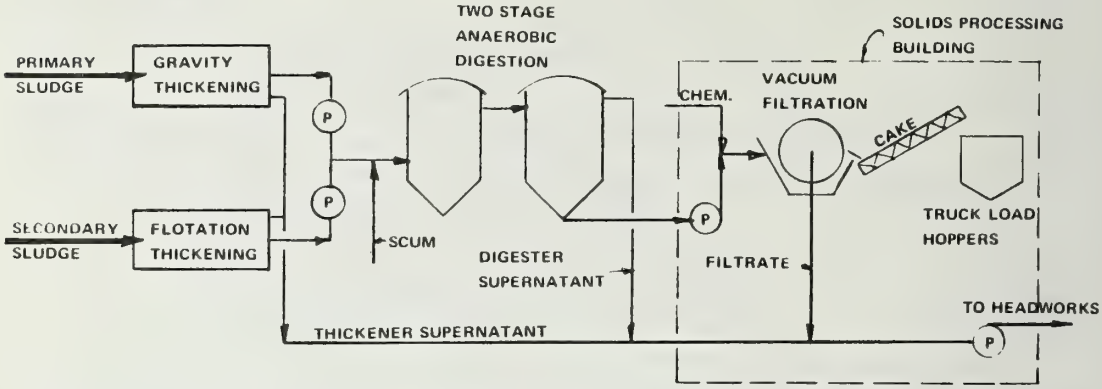
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A-2, B-2

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Gravity Thickening – 20 #/ft^2/day at 180 MGD; Flotation Thickening – 48 #/ft^2/day at 180 MGD; Digesters – 0.1 # VSS/ft^3/day and 20 day detention at 100 MGD; Vacuum Filters – 96#/ft^2/day at 100 MGD

NO. PROCESS UNITS: Gravity Thickening – 3; Flotation Thickening – 4; Digesters – 5; Vacuum Filters – 3

REDUNDANCY @ 100 MGD: One of each type (Thickening at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Gravity Thickening – 65' ϕ (3,320 ft^2); Flotation Thickening 20' x 30' (600 ft^2); Digesters – 95' ϕ x 35' (248,000 ft^3); Vacuum Filters – 12' ϕ x 16' (605 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 327
MAINTENANCE LABOR	94
POWER	117
FUEL	–
CHEMICALS	179
PARTS	100
SLUDGE HAUL	397
TOTAL ANNUAL O & M	1,214
CAPITAL COST	7,350

PRESENT VALUE OF COSTS:

O, M & R	11,535
CAPITAL	6,230
TOTAL	$17,765

FIGURE 6

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 3

MISCELLANEOUS OPERATING COSTS

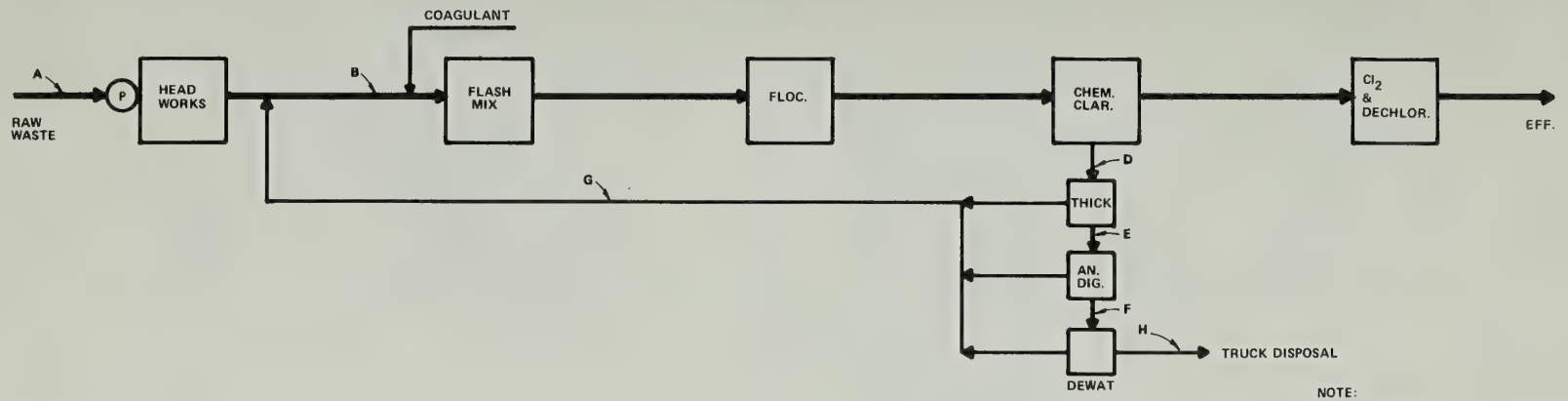
TREATMENT TRAIN: A-2

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 163
CLERICAL	66
LABORATORY	103
YARD WORK	50
TOTAL ANNUAL COST	382
PRESENT VALUE	$3,631

TRAIN A-3A

PRIMARY PHYSICAL/CHEMICAL ALUM

TREATMENT TRAIN A-3 // PHYSICAL - CHEMICAL TREATMENT FOR OCEAN DISCHARGE
– ALUM COAGULANT SYSTEM –



NOTE:

APPROXIMATE SITE AREA REQUIRED = 52 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A → POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B		D	E	F	G	H
Ave. Daily Flow Rate (mgd)	100	104.6			.70	–	4.6	–
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	187.6		–	1 14	–	7.6	–
Ave. Daily BOD_5 (1000 lbs./day)	200	–		–	–	–	–	-
Peak 24hr. BOD_5 (1000 lbs./day)	346	–		–	–	–	–	–
Ave. Suspended Solids (1000 lbs./day)	167			233	233	181	45	136
Peak 24hr. Suspended Solids (1000 lbs./day)	524			381	381	-	–	–
Percent Solids				0.6	4.0	4.0	–	20

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN A-3-A

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$10,740
Chemical Treatment	11,240	2,540	9,520	24,150	33,670
Solids Disposal	17,620	2,650	14,930	25,190	40,120
Chlorination–Dechlorination	1,990	290	1,690	2,730	4,420
SUBTOTAL	$37,380	$6,030	$31,670	$57,280	$88,950
Ancillary Systems and Facilities[5]	5,380	380	4,560	3,630	8,190
TOTAL	$42,760	$6,410	$36,230	$60,910	$97,140

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

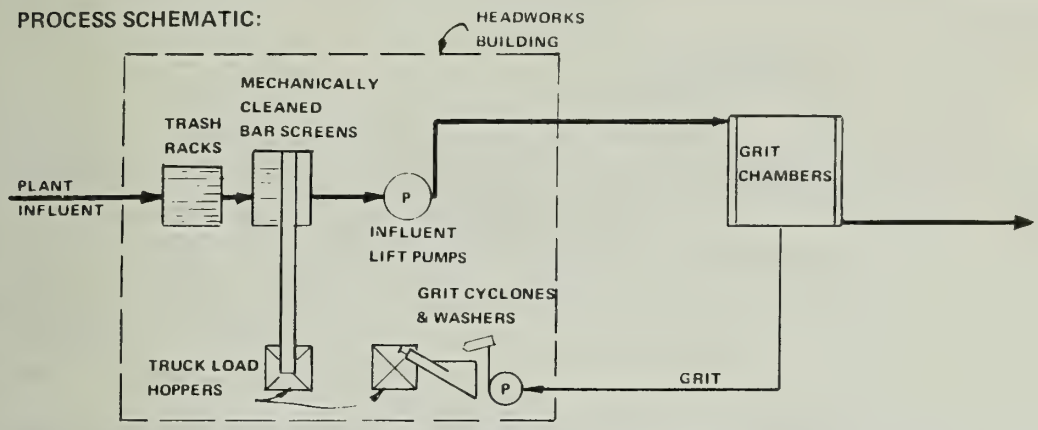
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, [A–3], B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548

CAPITAL COST 6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

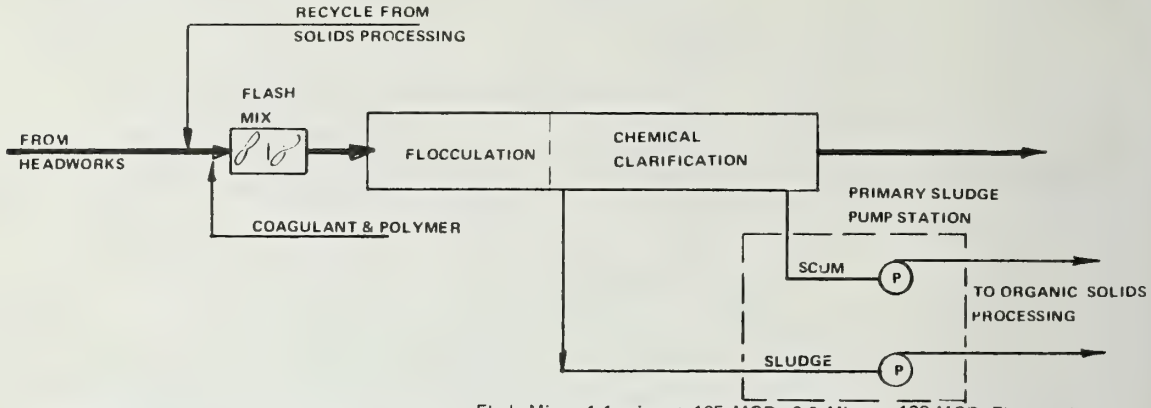
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–3, B–4, C–4

UNIT PROCESS: FLASH MIX, FLOCCULATION AND CHEMICAL CLARIFICATION, ALUM

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flash Mix: 1.1 min. at 105 MGD, 0.6 Min. at 188 MGD, Flocculation: 14.8 min. at 105 MGD, 8.2 Min. at 188 MGD. Clarification: 555 gpd/ft^2 at 100 MGD, 1,000 gpd/ft^2 at 180 MGD

NO. PROCESS UNITS: Flash Mix: 3 Basins, Flocculation: 20 Basins, Clarification: 20 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix 20'x20'x9' SWD; Flocculation 20'x30'x12 SWD; Clarification: 300'x30'x 12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 253
MAINTENANCE LABOR	22
POWER	86
FUEL	–
CHEMICALS	2,122
PARTS	41
MISCELLANEOUS	–
TOTAL ANNUAL O & M	2,542
CAPITAL COST	11,240

PRESENT VALUE OF COSTS:

O, M & R	24,154
CAPITAL	9,520
TOTAL	$33,674

FIGURE 3

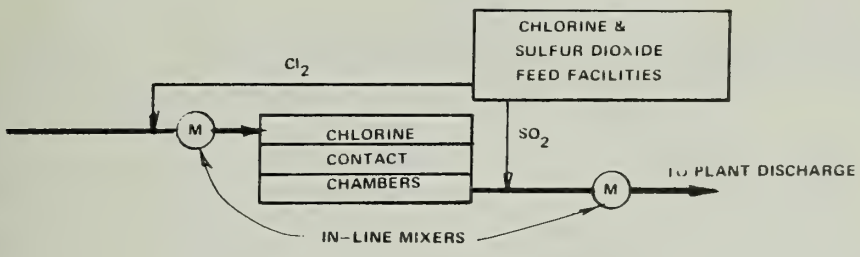
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$ 4,420

FIGURE 4

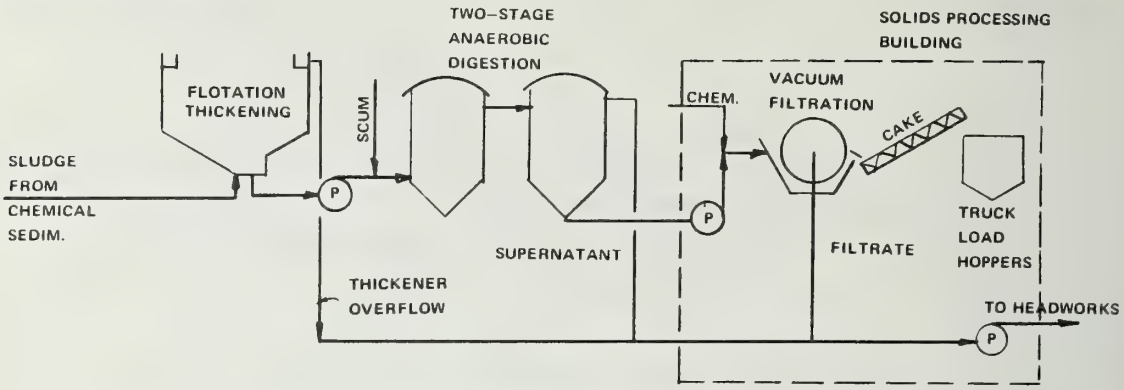
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–3, B–4, C–4

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING, ALUM

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flotation Thick. – 48 #/ft^2/day Digesters 0.1 # VSS/ft^3/day and 20 day detention vacuum filters 24 #/ft^2/day

NO. PROCESS UNITS: Float. Thick – 11; Digesters – 9; Vacuum Filters – 10

REDUNDANCY @ 100 MGD: One of each type (Thick. at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Flotation Thick. – 20'x40' (800 ft^2)
Digesters – 90' ϕ x 37' (236,000 ft^3)
Vacuum Filters – 12' ϕ x 24' (900 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 503
MAINTENANCE LABOR	151
POWER	374
FUEL	–
CHEMICALS	761
PARTS	240
SLUDGE HAUL	622
TOTAL ANNUAL O & M	2,651
CAPITAL COST	17,620

PRESENT VALUE OF COSTS:

O, M & R	25,190
CAPITAL	14,928
TOTAL	$40,118

FIGURE 5

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

MISCELLANEOUS OPERATING COSTS

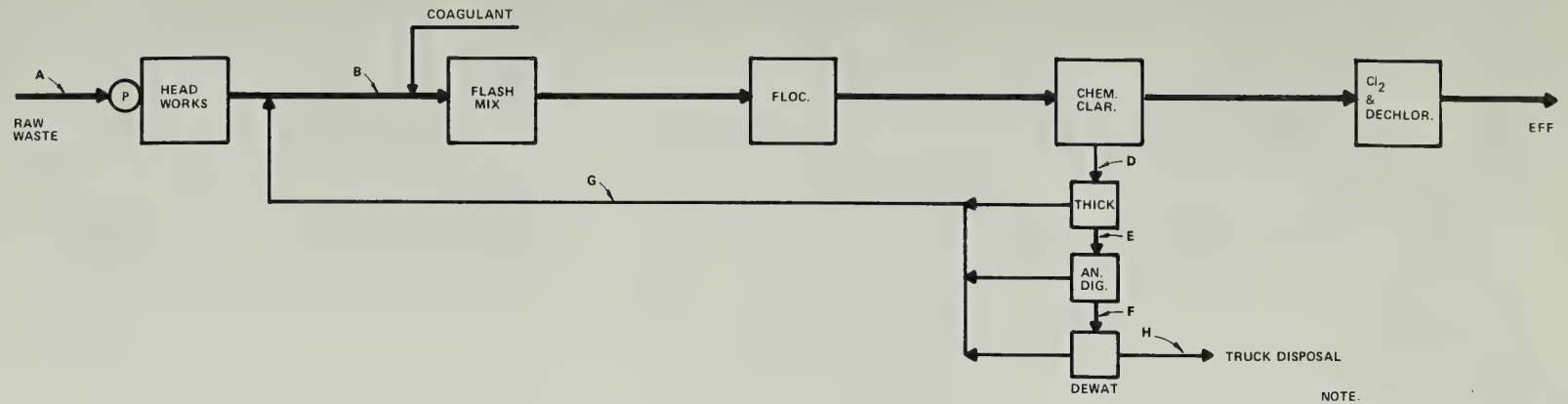
TREATMENT TRAIN: A-3 ALUM

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 163
CLERICAL	66
LABORATORY	103
YARD WORK	50
TOTAL ANNUAL COST	382
PRESENT VALUE	$3,631

TRAIN A-3F

PRIMARY PHYSICAL/CHEMICAL FERRIC CHLORIDE

TREATMENT TRAIN A-3 // PHYSICAL - CHEMICAL TREATMENT FOR OCEAN DISCHARGE
– FERRIC CHLORIDE COAGULANT SYSTEM –



NOTE.

APPROXIMATE SITE AREA REQUIRED = 55 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A → POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B		D	E	F	G	H
Ave. Daily Flow Rate (mgd)	100	104 6		–	.70	–	4.6	–
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	187.6		–	1.14	–	7 6	–
Ave. Daily BOD_5 (1000 lbs./day)	200			–	–	–	–	–
Peak 24hr. BOD_5 (1000 lbs./day)	346	–		–	–	–	–	–
Ave. Suspended Solids (1000 lbs./day)	167	–		233	233	181	45	136
Peak 24hr. Suspended Solids (1000 lbs./day)	524	–		381	381	-	–	–
Percent Solids	-	-		0.6	4 0	4.0	–	20

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN A-3-F

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$10,740
Chemical Treatment	11,240	3,040	9,520	28,910	38,430
Solids Disposal	15,710	2,390	13,310	22,710	36,020
Chlorination–Dechlorination	1,990	290	1,690	2,730	4,420
SUBTOTAL	$35,470	$6,270	$30,050	$59,560	$89,610
Ancillary Systems and Facilities[5]	5,380	380	4,560	3,630	8,190
TOTAL	$40,850	$6,650	$34,610	$63,190	$97,800

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

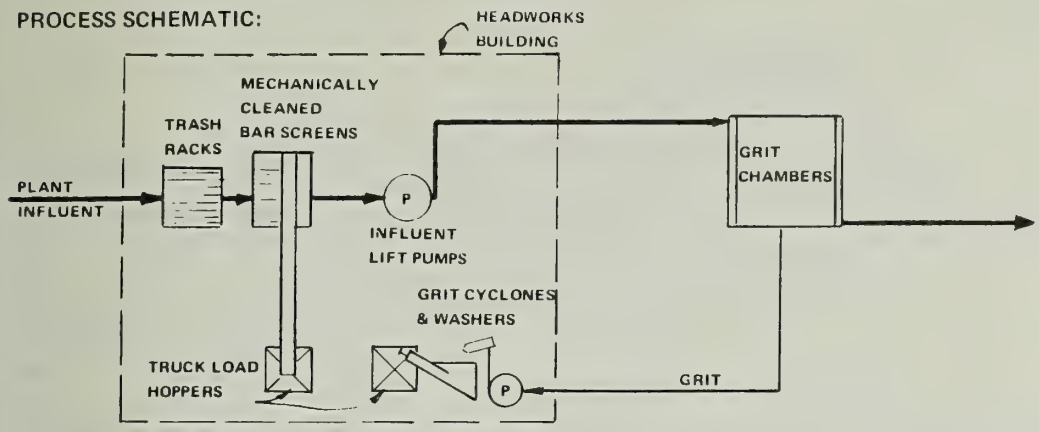
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, **A–3**, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

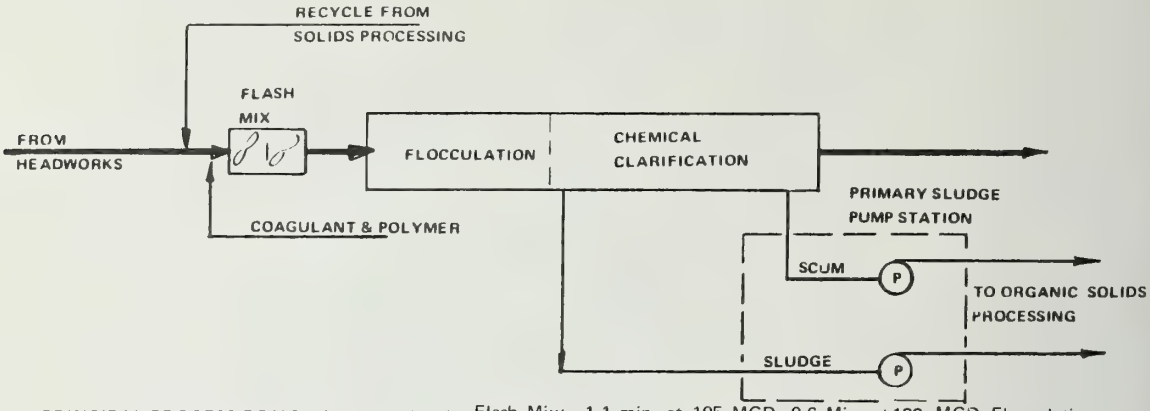
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: [A–3], B–4, C–4

UNIT PROCESS: FLASH MIX, FLOCCULATION AND CHEMICAL CLARIFICATION, FERRIC CHLORIDE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flash Mix: 1.1 min. at 105 MGD, 0.6 Min. at 188 MGD, Flocculation: 14.8 min. at 105 MGD, 8.2 Min. at 188 MGD. Clarification: 555 gpd/ft^2 at 100 MGD, 1,000 gpd/ft^2 at 180 MGD

NO. PROCESS UNITS: Flash Mix: 3 Basins, Flocculation: 20 Basins, Clarification: 20 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix 20'x20'x9' SWD; Flocculation 20'x30'x12 SWD; Clarification: 300'x30'x 12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 253
MAINTENANCE LABOR	26
POWER	86
FUEL	–
CHEMICALS	2,626
PARTS	41
MISCELLANEOUS	
TOTAL ANNUAL O & M	3,042
CAPITAL COST	11,240

PRESENT VALUE OF COSTS:

O, M & R	28,905
CAPITAL	9,520
TOTAL	$38,425

FIGURE 3

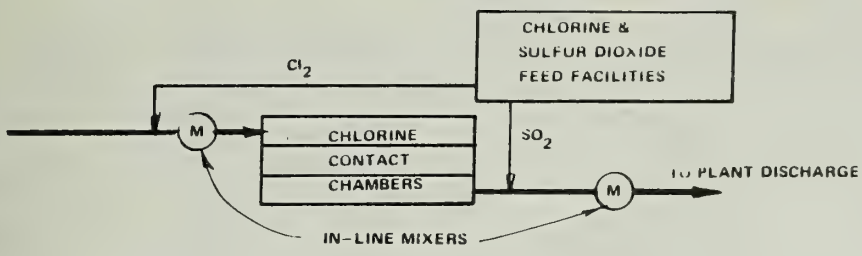
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, **A–3**, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 4

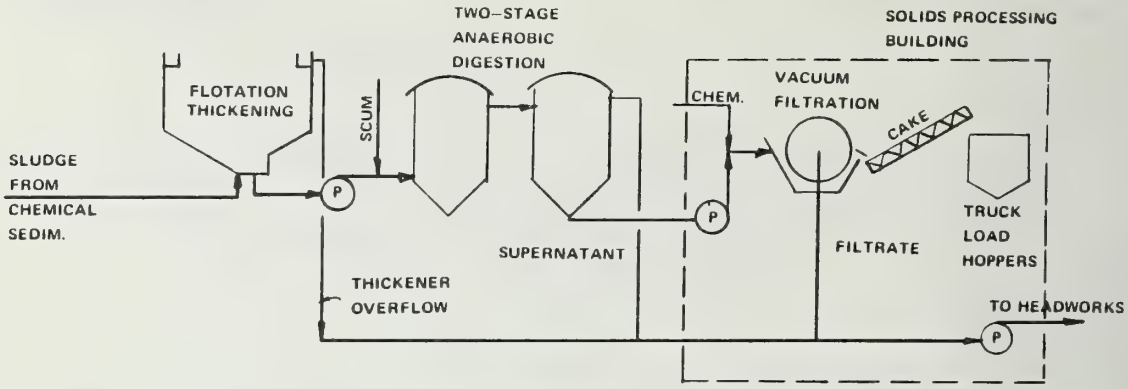
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: [A–3], B–4, C–4

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING, FERRIC CHLORIDE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flotation Thick. – 48 #/ft^2/day Digesters 0.1 # VSS/ft^3/day and 20 day detention vacuum filters 24 #/ft^2/day

NO. PROCESS UNITS: Float. Thick – 11; Digesters – 9; Vacuum Filters – 10

REDUNDANCY @ 100 MGD: One of each type (Thick. at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Flotation Thick. – 20'x40' (800 ft^2)
Digesters – 90' ϕ x 37' (236,000 ft^3)
Vacuum Filters – 12' ϕ x 24' (900 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 420
MAINTENANCE LABOR	101
POWER	276
FUEL	–
CHEMICALS	761
PARTS	210
SLUDGE HAUL	622
TOTAL ANNUAL O & M	2,390
CAPITAL COST	15,710

PRESENT VALUE OF COSTS:

O, M & R	22,710
CAPITAL	13,310
TOTAL	$36,020

FIGURE 5

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

MISCELLANEOUS OPERATING COSTS

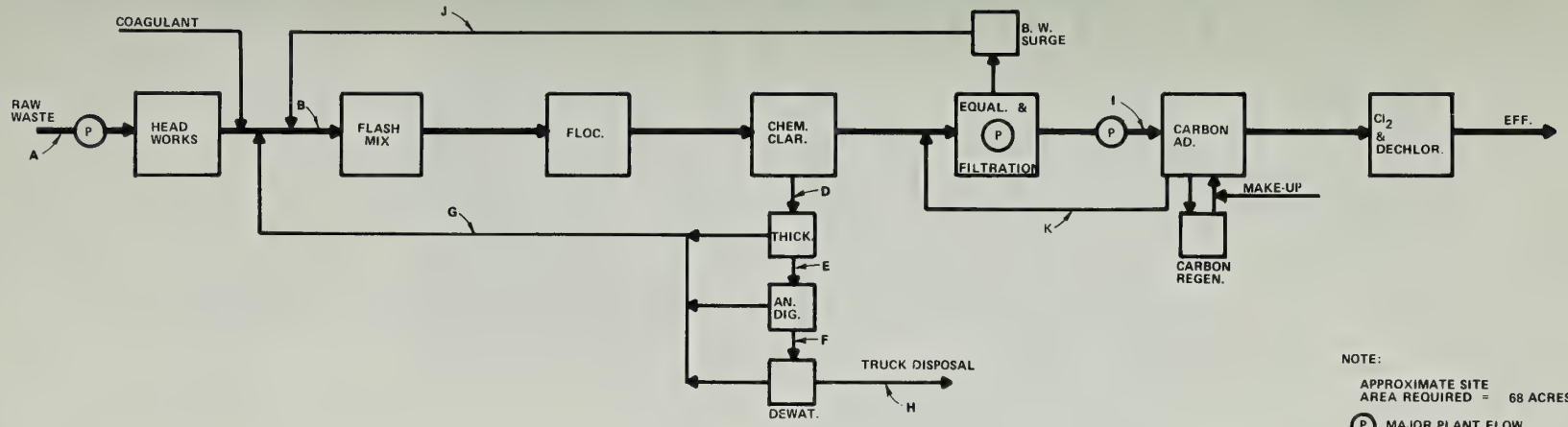
TREATMENT TRAIN: A-3 FERRIC CHLORIDE

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 163
CLERICAL	66
LABORATORY	103
YARD WORK	50
TOTAL ANNUAL COST	382
PRESENT VALUE	$3,631

TRAINS B-3A AND C-3A

TERTIARY PHYSICAL/CHEMICAL ALUM

TREATMENT TRAINS B-3 AND C-3 // PHYSICAL - CHEMICAL TREATMENT FOR EPA & BAY DISCHARGE STANDARDS
– ALUM COAGULANT SYSTEM –



NOTE:

APPROXIMATE SITE AREA REQUIRED = 68 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B		D	E	F	G	H	I	J	K
Ave. Daily Flow Rate (mgd)	100	114		–	.77	–	6.2	–	107	8	7
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	203		–	–	–	8 4	-	193	15	13
Ave. Daily BOD_5 (1000 lbs./day)	200	-		–	–	–	-	-	–	–	
Peak 24hr. BOD_5 (1000 lbs./day)	346	–		–	–	–	–			–	–
Ave. Suspended Solids (1000 lbs./day)	167	–		257	257	211	53	158		26	–
Peak 24hr. Suspended Solids (1000 lbs./day)	524			420	420	-	-		-	47	
Percent Solids		-		0 6	4	4	–	20		-	–

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

B-3A-1

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAINS B-3A AND C-3A

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$10,740
Chemical Treatment	12,810	2,540	10,850	24,140	34,990
Solids Disposal	19,100	2,980	16,180	28,270	44,450
Filtration	14,540	700	12,320	6,600	18,920
Carbon Adsorption and Regen.	26,850	2,430	22,750	23,130	45,880
Chlorination–Dechlorination	1,990	290	1,690	2,730	4,420
SUBTOTAL	$81,820	$9,490	$69,320	$90,080	$159,400
Ancillary Systems and Facilities[5]	12,300	400	10,420	3,810	14,230
TOTAL	$94,120	$9,890	$79,740	$93,890	$173,630

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

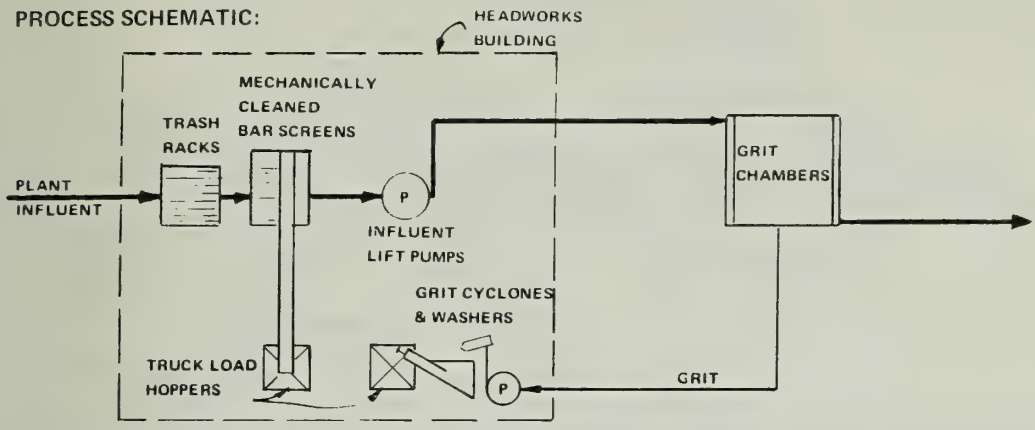
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, **B–3**, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

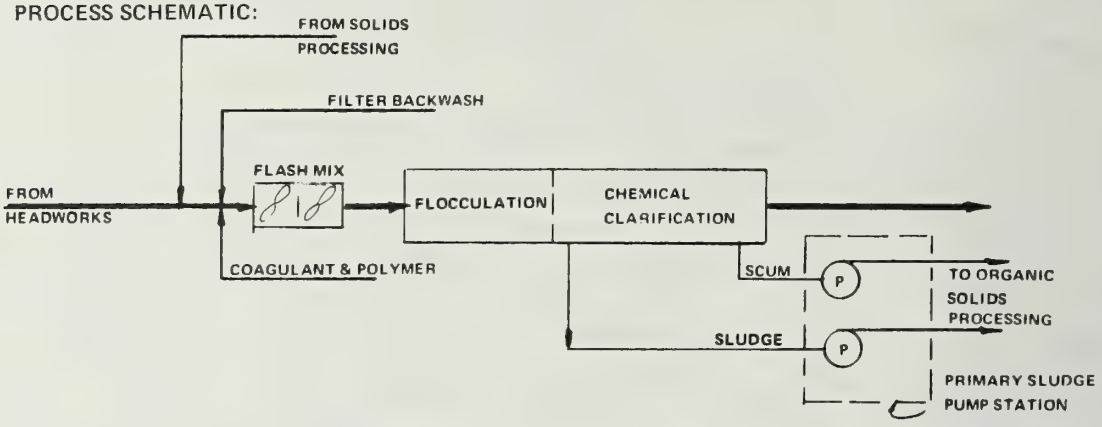
PROCESS UNIT DATA
COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B-3, C-3

UNIT PROCESS: FLASH MIX, FLOCCULATION & CHEMICAL CLARIFICATION, ALUM

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flash Mix: 1.02 min. at 114 MGD, 0.6 min. at 203 MGD, Flocculation: 15 min. at 114 MGD, 8.4 min. at 203 MGD. Clarification: 575 gpd/ft² at 114 MGD, 980 gpd/ft² at 203 MGD

NO. PROCESS UNITS: Flash Mix: 3 Basins, Flocculation: 23 Basins, Clarifications: 23 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix – 20'x20'x9' SWD; Flocculation – 20'x30'x12' SWD; Clarification – 300'x30'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 263
MAINTENANCE LABOR	22
POWER	86
FUEL	–
CHEMICALS	2,122
PARTS	47
MISCELLANEOUS	–
TOTAL ANNUAL O & M	2,540
CAPITAL COST	12,810

PRESENT VALUE OF COSTS:

O, M & R	24,135
CAPITAL	10,850
TOTAL	$34,985

FIGURE 3

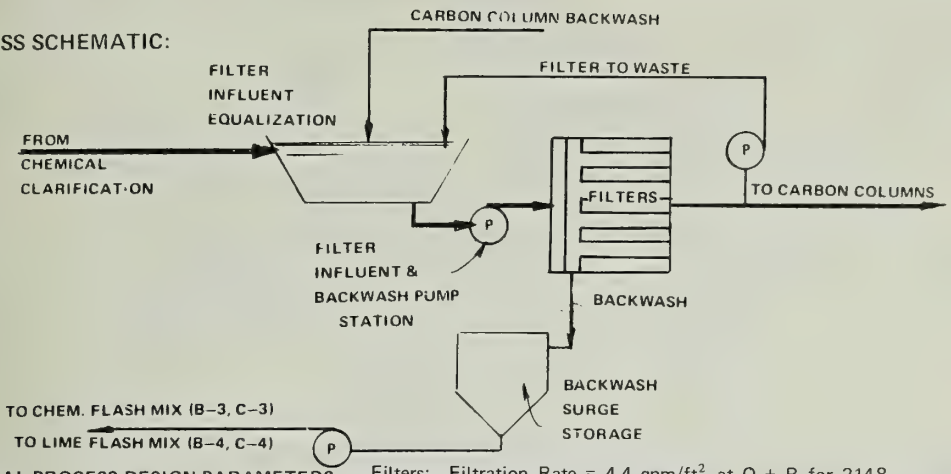
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, C–3, B–4, C–4

UNIT PROCESS: FILTRATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Filters: Filtration Rate = 4.4 gpm/ft^2 at Q + R for 2148 2.5 gpm/ft^2 at Q + R for 121.3 MGD. Filter runs = 8 hrs. Backwash Rate = 20 gpm/ft^2, Surface Wash = 0.6 gpm/ft^2

NO. PROCESS UNITS: 36 Filters

REDUNDANCY @ 100 MGD: 1 Filter

INDIVIDUAL PROCESS UNIT SIZE: 32 ft. x 32 ft.

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 146
MAINTENANCE LABOR	68
POWER	183
FUEL	–
CHEMICALS	182
PARTS	116
MISCELLANEOUS	
TOTAL ANNUAL O & M	695
CAPITAL COST	14,540

PRESENT VALUE OF COSTS:

O, M & R	6,604
CAPITAL	12,318
TOTAL	$18,922

FIGURE 4

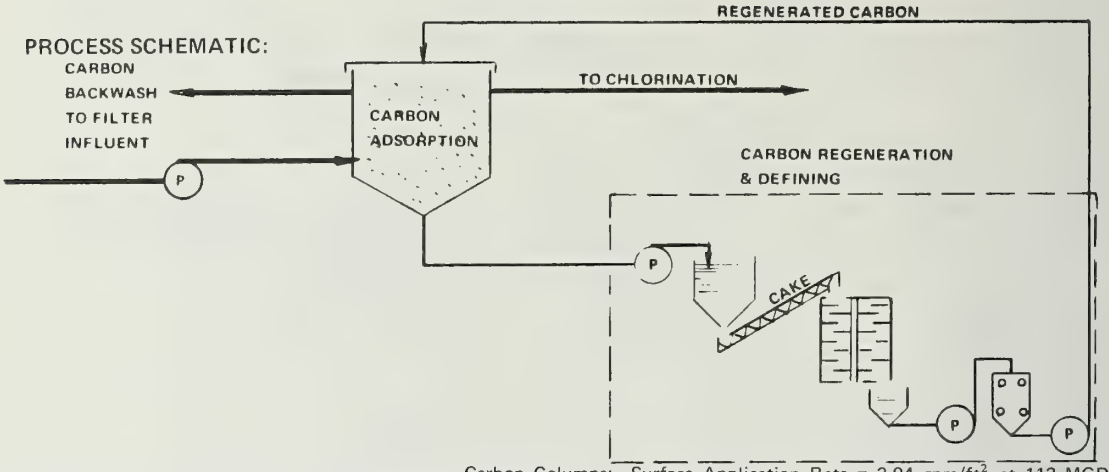
PROCESS UNIT DATA
COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, B–4, C–3, C–4

UNIT PROCESS: CARBON TREATMENT & CARBON REGENERATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Carbon Columns: Surface Application Rate = 3.94 gpm/ft^2 at 113 MGD, Backwash Rate – 16 gpm/ft^2, Carbon Dose = 1,300 lbs/MG Contact Time = 36 min. Carbon Furnances: Hearth Loading – 41 lbs/ft^2/day at 100 MG

NO. PROCESS UNITS: 30 Columns; 3 Furnaces

REDUNDANCY @ 100 MGD:

INDIVIDUAL PROCESS UNIT SIZE: Carbon Columns – 26 ft. sq. x 18 ft. carbon depth
Carbon Furnaces – 22'-3" OD x 6 Hearth

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 249
MAINTENANCE LABOR	35
POWER	302
FUEL	165
CHEMICALS	1,549
PARTS	134
MISCELLANEOUS	
TOTAL ANNUAL O & M	2,434
CAPITAL COST	26,850

PRESENT VALUE OF COSTS:

O, M & R	23,128
CAPITAL	22,747
TOTAL	$45,875

FIGURE 5

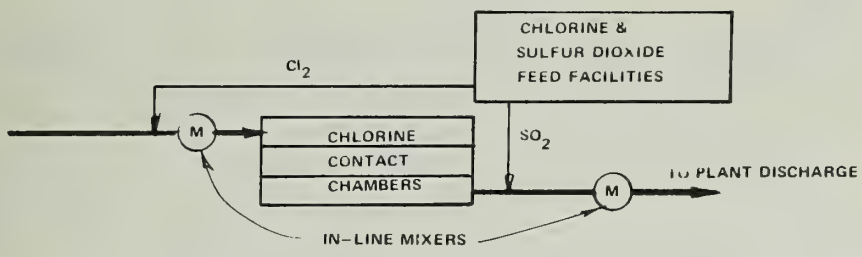
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, **B–3**, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287

CAPITAL COST 1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 6

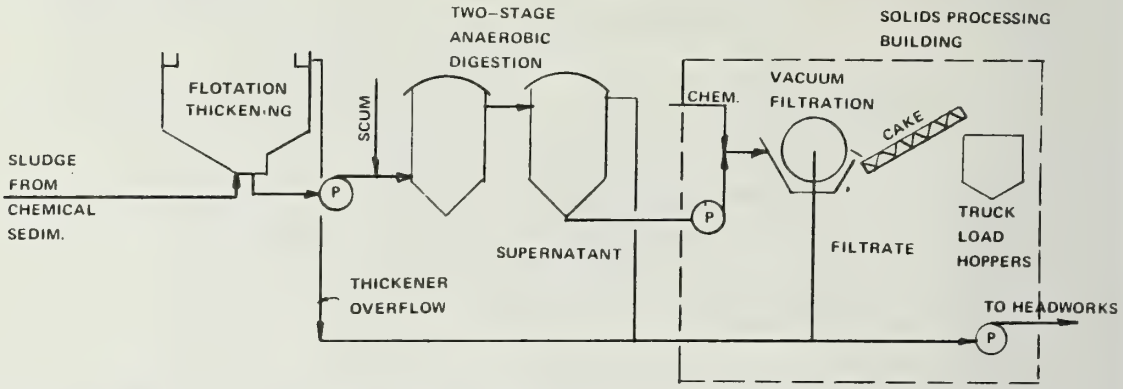
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, C–3,

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING, ALUM

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flotation Thick. – 48 #/ft^2/day
Digesters – 0.1 # VSS/ft^3/day and 20 day detention
Vacuum Filters – 24 #/ft^2/day

NO. PROCESS UNITS: Flotation Thick.– 12; Digesters – 9; Vacuum Filters – 11

REDUNDANCY @ 100 MGD: One of each type (thickening at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Flotation Thick. – 20'x40' (800 ft^2)
Digesters – 95' ϕ x 37' (262,000 ft^3)
Vacuum Filters – 12' ϕ x 24' (900 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 582
MAINTENANCE LABOR	133
POWER	413
FUEL	–
CHEMICALS	867
PARTS	260
SLUDGE HAUL	720
TOTAL ANNUAL O & M	2,975
CAPITAL COST	19,100

PRESENT VALUE OF COSTS:

O, M & R	28,268
CAPITAL	16,182
TOTAL	$44,450

FIGURE 7

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

MISCELLANEOUS OPERATING COSTS

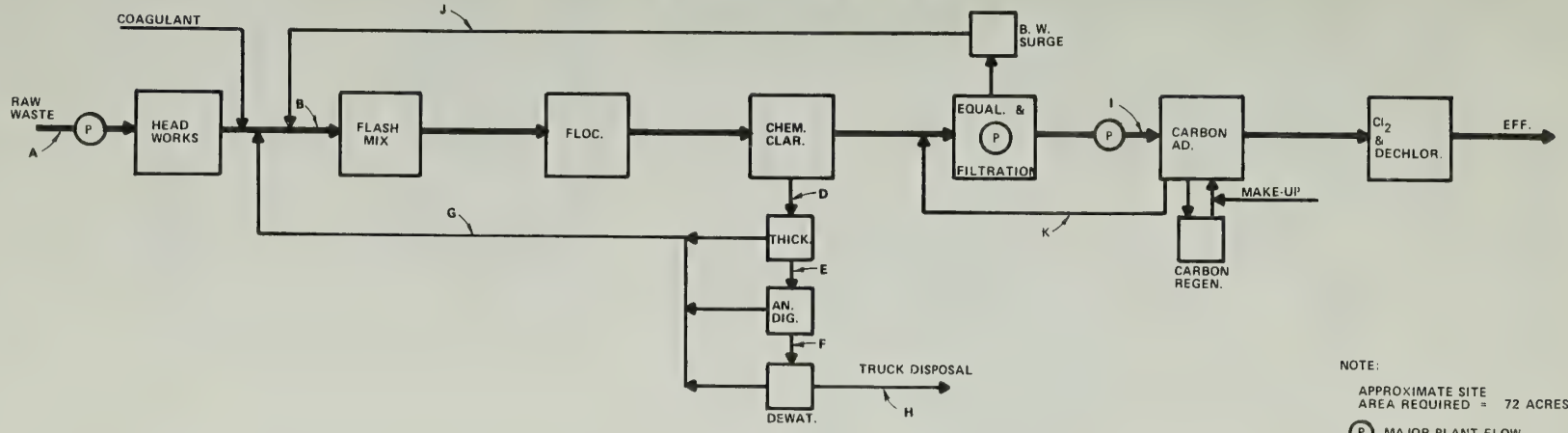
TREATMENT TRAIN: B-3 ALUM

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 170
CLERICAL	69
LABORATORY	107
YARD WORK	55
TOTAL ANNUAL COST	401
PRESENT VALUE	$3,808

TRAINS B-3F AND C3-F

TERTIARY PHYSICAL/CHEMICAL FERRIC CHLORIDE

TREATMENT TRAINS B-3 AND C-3 // PHYSICAL - CHEMICAL TREATMENT FOR EPA & BAY DISCHARGE STANDARDS
– FERRIC CHLORIDE COAGULANT SYSTEM –



NOTE:

APPROXIMATE SITE AREA REQUIRED = 72 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B		D	E	F	G	H	I	J	K
Ave. Daily Flow Rate (mgd)	100	114			77	–	62	–	107	8	7
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	203			–	–	84	-	193	15	13
Ave. Daily BOD_5 (1000 lbs./day)	200				–	–	-	–	–	–	–
Peak 24hr. BOD_5 (1000 lbs./day)	346				-	–	–	–	.		
Ave. Suspended Solids (1000 lbs./day)	167			257	257	211	53	158		26	
Peak 24hr. Suspended Solids (1000 lbs./day)	524			420	420	-	-		-	47	
Percent Solids				06	4	4	–	20	-		

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

B-3F-1

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAINS B-3F AND C-3F

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$10,740
Chemical Treatment	12,810	3,060	10,850	29,060	39,910
Solids Disposal	17,030	2,710	14,430	25,700	40,130
Filtration	14,540	700	12,320	6,600	18,920
Carbon Adsorption and Regen.	26,850	2,430	22,750	23,130	45,880
Chlorination–Dechlorination	1,990	290	1,690	2,730	4,420
SUBTOTAL	$79,750	$9,740	$67,570	$92,430	$160,000
Ancillary Systems and Facilities[5]	12,300	400	10,420	3,810	14,230
TOTAL	$92,050	$10,140	$77,990	$96,240	$174,230

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

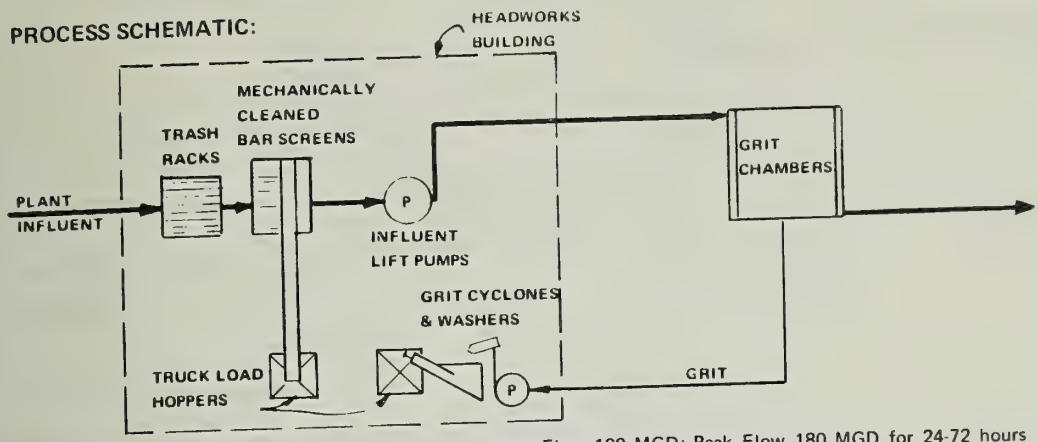
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, **B–3**, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

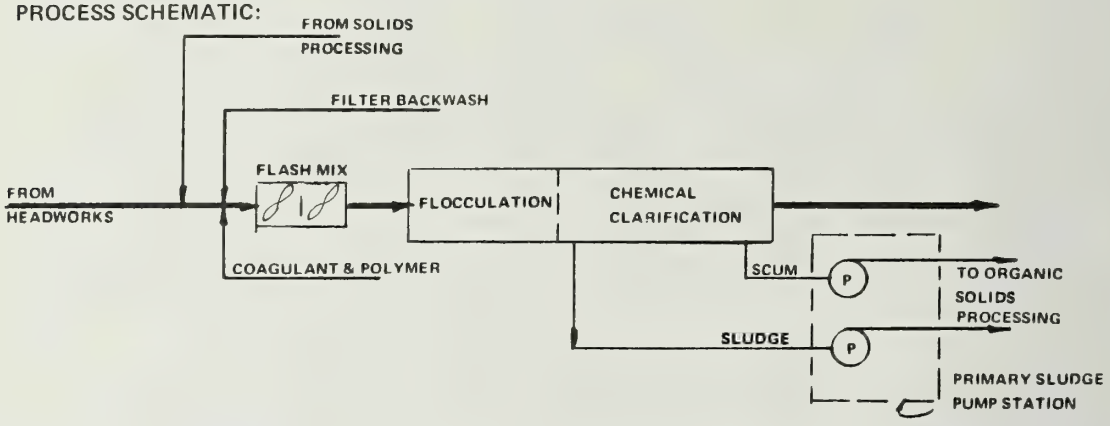
PROCESS UNIT DATA
COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B-3, C-3

UNIT PROCESS: FLASH MIX, FLOCCULATION & CHEMICAL CLARIFICATION, FERRIC CHLORIDE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flash Mix: 1.3 min. at 114 MGD, 0.7 min. at 203 MGD, Flocculation: 15 min. at 114 MGD, 8.7 min. at 203 MGD. Clarification: 575 gpd/ft^2 at 114 MGD, 995 gpd/ft^2 at 203 MGD

NO. PROCESS UNITS: Flash Mix: 3 Basins, Flocculation: 23 Basins, Clarifications: 24 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix – 20'x20'x9' SWD; Flocculation – 20'x30'x12' SWD; Clarification – 300'x30'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 273
MAINTENANCE LABOR	26
POWER	86
FUEL	–
CHEMICALS	2,626
PARTS	47
MISCELLANEOUS	
TOTAL ANNUAL O & M	3,058
CAPITAL COST	12,810

PRESENT VALUE OF COSTS:

O, M & R	29,057
CAPITAL	10,850
TOTAL	$39,907

FIGURE 3

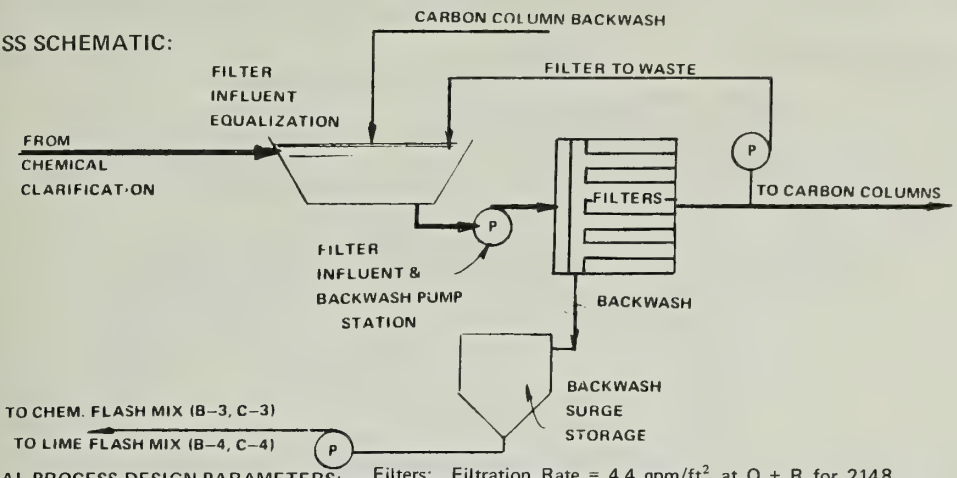
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, C–3, B–4, C–4

UNIT PROCESS: FILTRATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Filters: Filtration Rate = 4.4 gpm/ft^2 at Q + R for 2148 2.5 gpm/ft^2 at Q + R for 121.3 MGD. Filter runs = 8 hrs. Backwash Rate = 20 gpm/ft^2, Surface Wash = 0.6 gpm/ft^2

NO. PROCESS UNITS: 36 Filters

REDUNDANCY @ 100 MGD: 1 Filter

INDIVIDUAL PROCESS UNIT SIZE: 32 ft. x 32 ft.

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 146
MAINTENANCE LABOR	68
POWER	183
FUEL	–
CHEMICALS	182
PARTS	116
MISCELLANEOUS	
TOTAL ANNUAL O & M	695

CAPITAL COST 14,540

PRESENT VALUE OF COSTS:

O, M & R	6,604
CAPITAL	12,318
TOTAL	$18,922

FIGURE 4

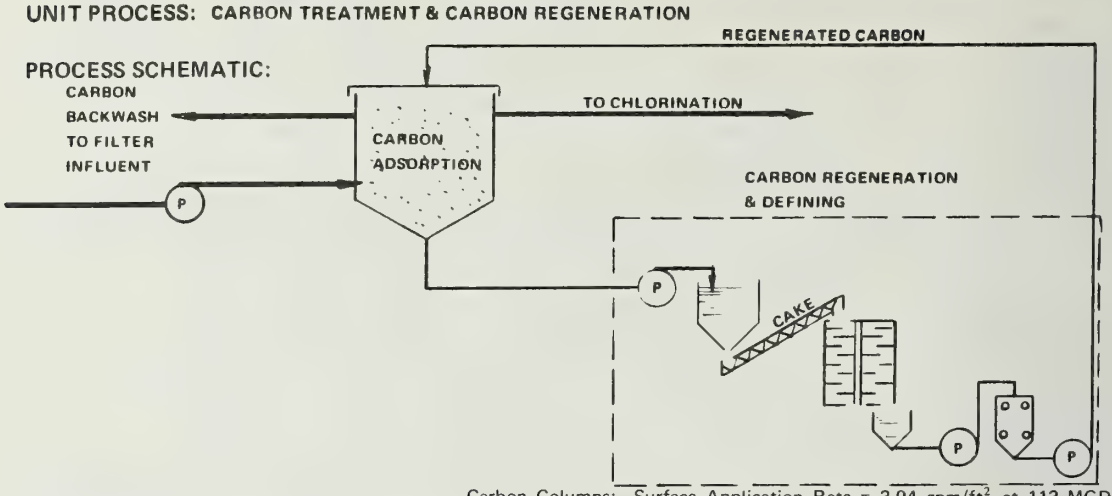
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, B–4, C–3, C–4

UNIT PROCESS: CARBON TREATMENT & CARBON REGENERATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Carbon Columns: Surface Application Rate = 3.94 gpm/ft^2 at 113 MGD, Backwash Rate – 16 gpm/ft^2, Carbon Dose = 1,300 lbs/MG Contact Time = 36 min. Carbon Furnances: Hearth Loading – 41 lbs/ft^2/day at 100 MG

NO. PROCESS UNITS: 30 Columns; 3 Furnaces

REDUNDANCY @ 100 MGD:

INDIVIDUAL PROCESS UNIT SIZE: Carbon Columns – 26 ft. sq. x 18 ft. carbon depth
Carbon Furnaces – 22'-3" OD x 6 Hearth

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 249
MAINTENANCE LABOR	35
POWER	302
FUEL	165
CHEMICALS	1,549
PARTS	134
MISCELLANEOUS	
TOTAL ANNUAL O & M	2,434
CAPITAL COST	26,850

PRESENT VALUE OF COSTS:

O, M & R	23,128
CAPITAL	22,747
TOTAL	$45,875

FIGURE 5

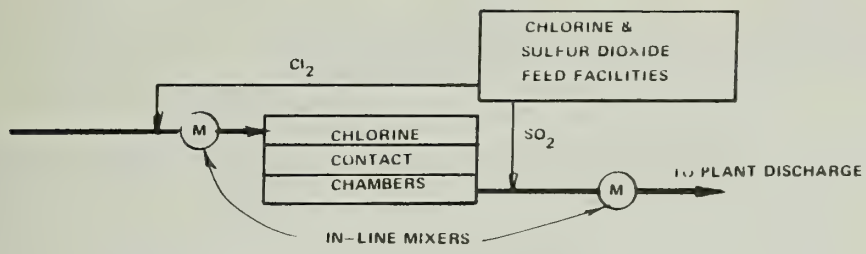
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 6

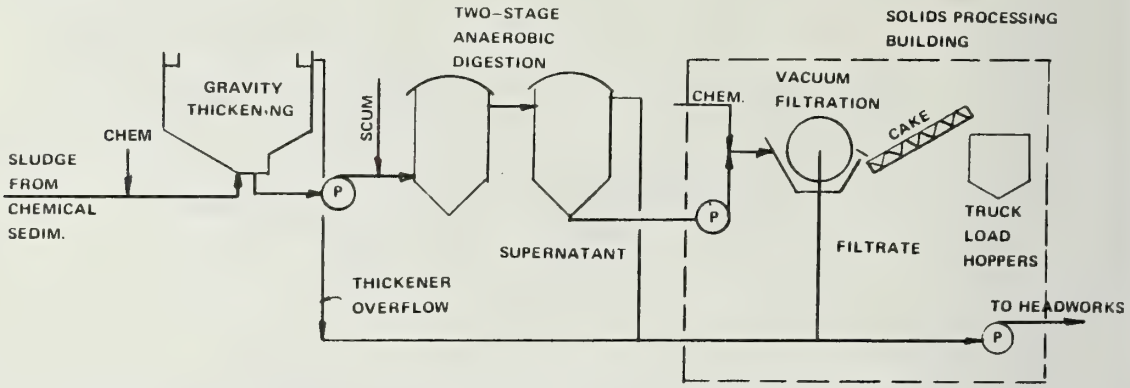
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: [B-3], C-3,

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING, FERRIC CHLORIDE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flotation Thick. – 48 #/ft^2/day
Digesters – 0.1 # VSS/ft^3/day and 20 day detention
Vacuum Filters – 24 #/ft^2/day

NO. PROCESS UNITS: Flotation Thick.– 12; Digesters – 9; Vacuum Filters – 11

REDUNDANCY @ 100 MGD: One of each type (thickening at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Flotation Thick. – 20'x40' (800 ft^2)
Digesters – 95' ϕ x 37' (262,000 ft^3)
Vacuum Filters – 12' ϕ x 24' (900 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 492
MAINTENANCE LABOR	91
POWER	305
FUEL	–
CHEMICALS	867
PARTS	230
SLUDGE HAUL	720
TOTAL ANNUAL O & M	2,705
CAPITAL COST	17,030

PRESENT VALUE OF COSTS:

O, M & R	25,702
CAPITAL	14,428
TOTAL	$ 40,130

FIGURE 7

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

MISCELLANEOUS OPERATING COSTS

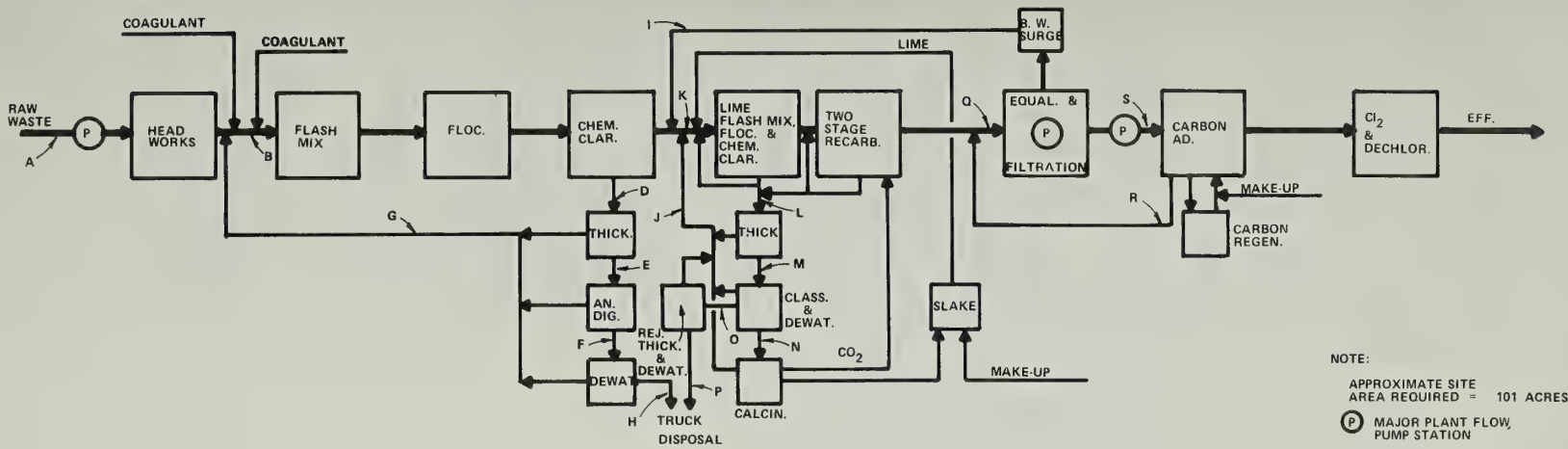
TREATMENT TRAIN: B-3 FERRIC CHLORIDE

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 170
CLERICAL	69
LABORATORY	107
YARD WORK	55
TOTAL ANNUAL COST	401
PRESENT VALUE	$3,808

TRAINS B-4A AND C-4A

TERTIARY PHYSICAL/CHEMICAL
ALUM - LIME

TREATMENT TRAINS B-4 AND C-4 // PHYSICAL - CHEMICAL TREATMENT FOR EPA & BAY DISCHARGE STANDARDS
– ALUM COAGULANT SYSTEM –



NOTE:

APPROXIMATE SITE AREA REQUIRED = 101 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B		D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Ave. Daily Flow Rate (mgd)	100	104.6		–	0.7	–	4.6	–	8	9.8	117.8	9.8	1.2	–	1.28	–	115	7	107
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	107.6			1.14	–	7.6	–	15	12.5	207.5	12.6	1.6	–	1.0	–	128	13	193
Ave. Daily BOD_5 (1000 lbs./day)	200	–			–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Peak 24hr. BOD_5 (1000 lbs./day)	346	–			–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ave. Suspended Solids (1000 lbs./day)	167			233	233	181	45	136	5		–	820	820	570	250	320	–	–	–
Peak 24hr. Suspended Solids (1000 lbs./day)	524			381	381	–	–	–	9		–	1050	1050	730	320	–	–	–	–
Percent Solids	–	–		0.06	4	4	–	20	–	–	–	1	8	55	3	14	–	–	–

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

B-4A-1

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAINS B-4A AND C-4A

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$10,740
Chemical Treatment	11,240	2,540	9,520	24,150	33,670
Solids Disposal	17,620	2,650	14,930	25,190	40,120
Lime Treatment	14,970	1,460	12,680	13,890	26,570
Lime Recovery	28,400	1,700	24,060	16,120	40,180
Filtration	14,540	700	12,320	6,600	18,920
Carbon Adsorption and Regen.	26,850	2,430	22,750	23,130	45,880
Chlorination–Dechlorination	1,990	290	1,690	2,730	4,420
SUBTOTAL	$122,140	$12,320	$103,480	$117,020	$220,500
Ancillary Systems and Facilities[5]	18,220	410	15,440	3,880	19,320
TOTAL	$140,360	$12,730	$118,920	$120,900	$239,820

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

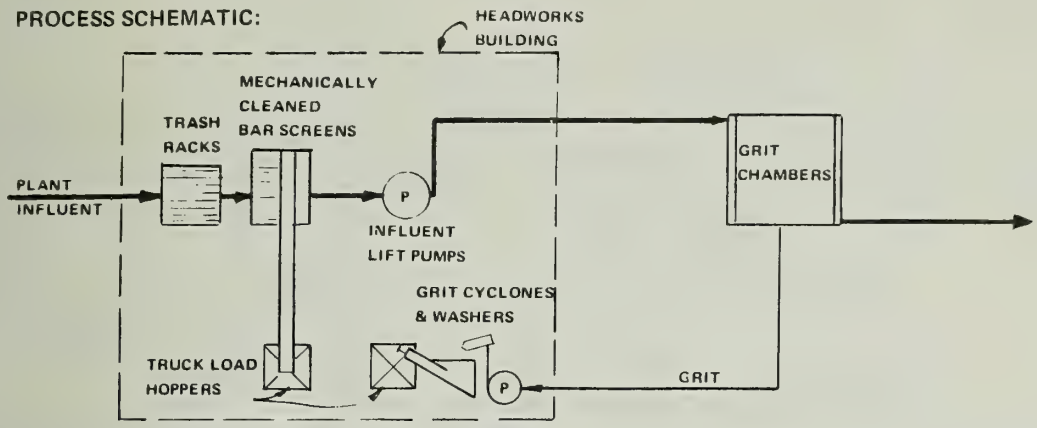
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, **B–4**, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

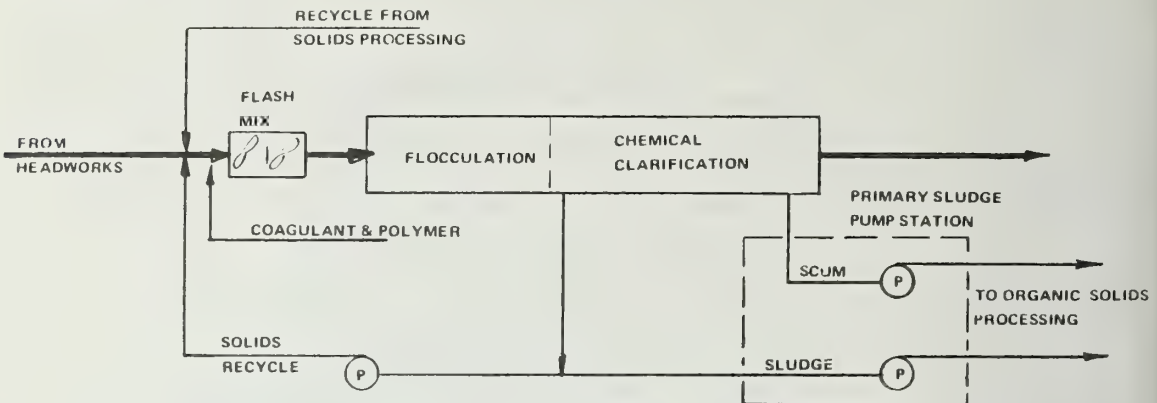
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A-3, B-4, C-4

UNIT PROCESS: FLASH MIX, FLOCCULATION AND CHEMICAL CLARIFICATION, ALUM

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flash Mix: 1.1 min. at 105 MGD, 0.6 Min. at 188 MGD, Flocculation: 14.8 min. at 105 MGD, 8.2 Min. at 188 MGD. Clarification: 555 gpd/ft^2 at 100 MGD, 1,000 gpd/ft^2 at 180 MGD

NO. PROCESS UNITS: Flash Mix: 3 Basins, Flocculation: 20 Basins, Clarification: 20 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix 20'x20'x9' SWD; Flocculation 20'x30'x12 SWD; Clarification: 300'x30'x 12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 253
MAINTENANCE LABOR	22
POWER	86
FUEL	–
CHEMICALS	2,122
PARTS	41
MISCELLANEOUS	
TOTAL ANNUAL O & M	2,542
CAPITAL COST	11,240

PRESENT VALUE OF COSTS:

O, M & R	24,154
CAPITAL	9,520
TOTAL	$33,674

FIGURE 3

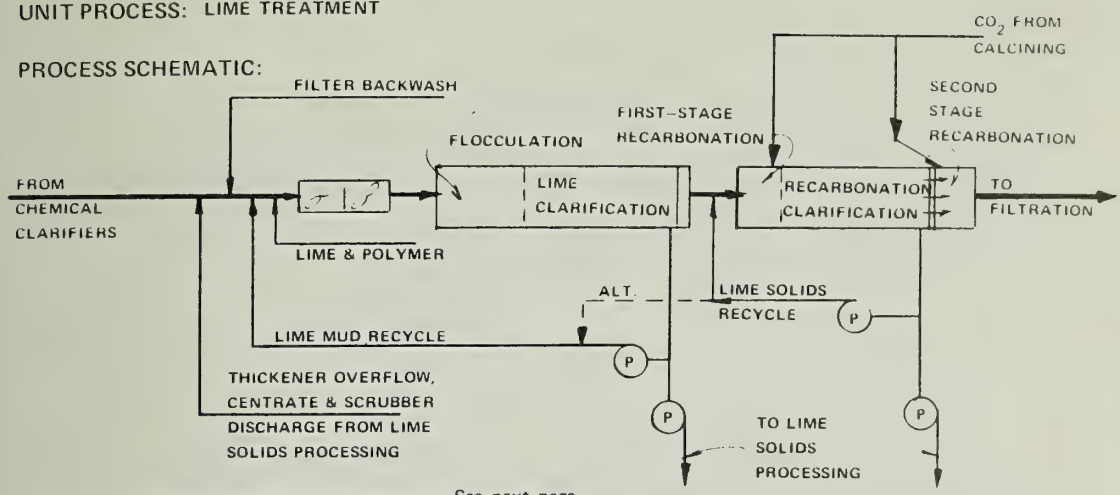
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–4, C–4

UNIT PROCESS: LIME TREATMENT

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: See next page

NO. PROCESS UNITS: Flash Mix: 3 basins, Flocculation: 12 basins; Clarification: 12 basins; 1st Stage Recarbonation: 12 basins; Recarbonation Clarification: 12 basins; 2nd Stage Recarbonation: 12 basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix – 20'x20'x12' SWD; Flocculation – 40'x30'x12' SWD; Clarification – 300'x30'x12' SWD; 1st Stage Recarbonation – 20'x30'x12' SWD; Recarbonation Clarification – 300'x30'x12' SWD 2nd Stage Recarbonation – 30'x21'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 93
MAINTENANCE LABOR	26
POWER	323
FUEL	–
CHEMICALS	960
PARTS	60
MISCELLANEOUS	–
TOTAL ANNUAL O & M	1,462
CAPITAL COST	14,971

PRESENT VALUE OF COSTS:

O, M & R	13,891
CAPITAL	12,683
TOTAL	$26,574

FIGURE 4

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

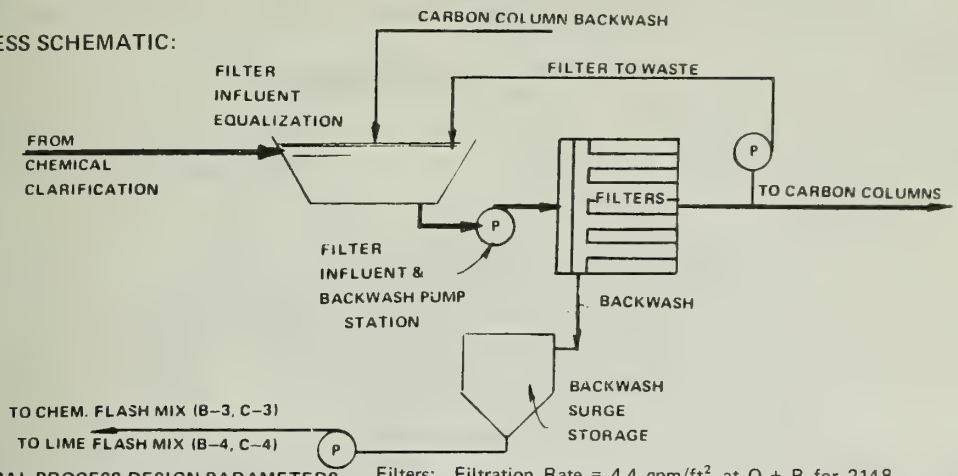
LIME TREATMENT

PARAMETER	AVERAGE DAY	MAXIMUM DAY
FLASH MIX		
Q + R, mgd	112	208
Detention Time, min.	1.4	0.8
FLOCCULATION		
Q + R, mgd	112	208
Detention Time, min.	16.6	9
CLARIFICATION		
Q + R – Sludge Drawoff, mgd	107	194
SOR, gpd/ft^2	990	1,800
1ST STAGE RECARBONATION		
Q + R, mgd	110	202
Detention Time, min.	9.3	5.1
RECARBONATION CLARIFICATION		
Q + R – Sludge Drawoff, mgd	108	194
SOR, gpd/ft^2	1,000	1,800
2ND STAGE RECARBONATION		
Q + R, mgd	108	194
Detention Time, min.	8.9	5

TREATMENT TRAIN: B–3, C–3, **B–4**, C–4

UNIT PROCESS: FILTRATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Filters: Filtration Rate = 4.4 gpm/ft^2 at Q + R for 2148 2.5 gpm/ft^2 at Q + R for 121.3 MGD. Filter runs = 8 hrs. Backwash Rate = 20 gpm/ft^2, Surface Wash = 0.6 gpm/ft^2

NO. PROCESS UNITS: 36 Filters

REDUNDANCY @ 100 MGD: 1 Filter

INDIVIDUAL PROCESS UNIT SIZE: 32 ft. x 32 ft.

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 146
MAINTENANCE LABOR	68
POWER	183
FUEL	–
CHEMICALS	182
PARTS	116
MISCELLANEOUS	
TOTAL ANNUAL O & M	695
CAPITAL COST	14,540

PRESENT VALUE OF COSTS:

O, M & R	6,604
CAPITAL	12,318
TOTAL	$18,922

FIGURE 5

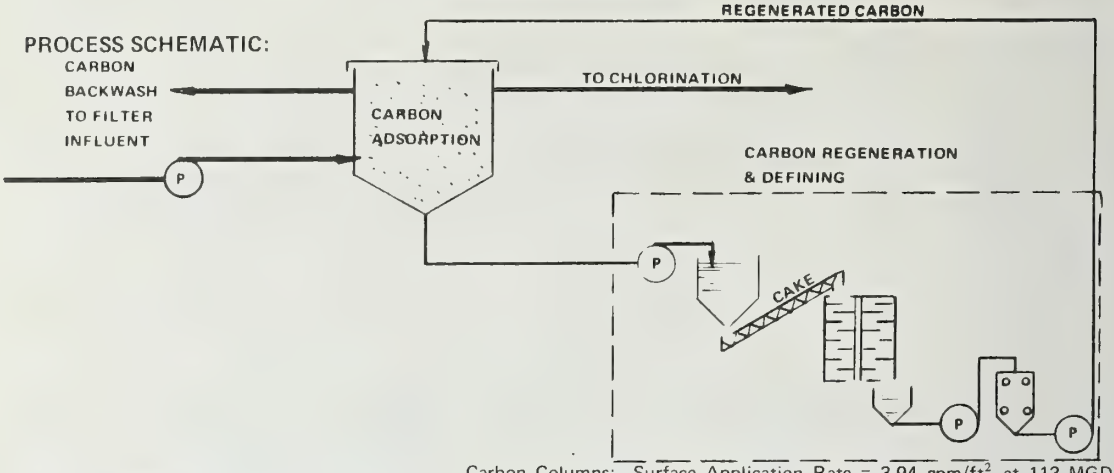
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, **B–4**, C–3, C–4

UNIT PROCESS: CARBON TREATMENT & CARBON REGENERATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Carbon Columns: Surface Application Rate = 3.94 gpm/ft^2 at 113 MGD, Backwash Rate – 16 gpm/ft^2, Carbon Dose = 1,300 lbs/MG Contact Time = 36 min. Carbon Furnances: Hearth Loading – 41 lbs/ft^2/day at 100 MG

NO. PROCESS UNITS: 30 Columns; 3 Furnaces

REDUNDANCY @ 100 MGD:

INDIVIDUAL PROCESS UNIT SIZE: Carbon Columns – 26 ft. sq. x 18 ft. carbon depth
Carbon Furnaces – 22'-3" OD x 6 Hearth

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 249
MAINTENANCE LABOR	35
POWER	302
FUEL	165
CHEMICALS	1,549
PARTS	134
MISCELLANEOUS	
TOTAL ANNUAL O & M	2,434
CAPITAL COST	26,850

PRESENT VALUE OF COSTS:

O, M & R	23,128
CAPITAL	22,747
TOTAL	$45,875

FIGURE 6

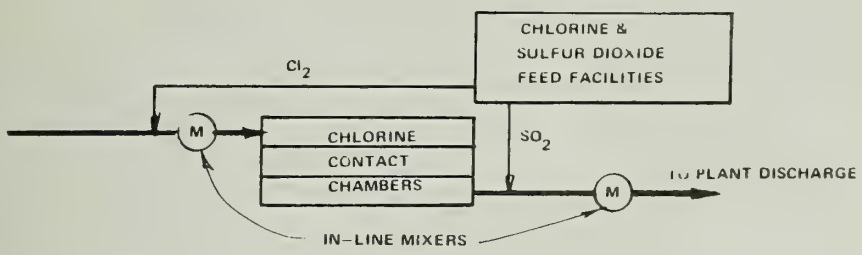
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 7

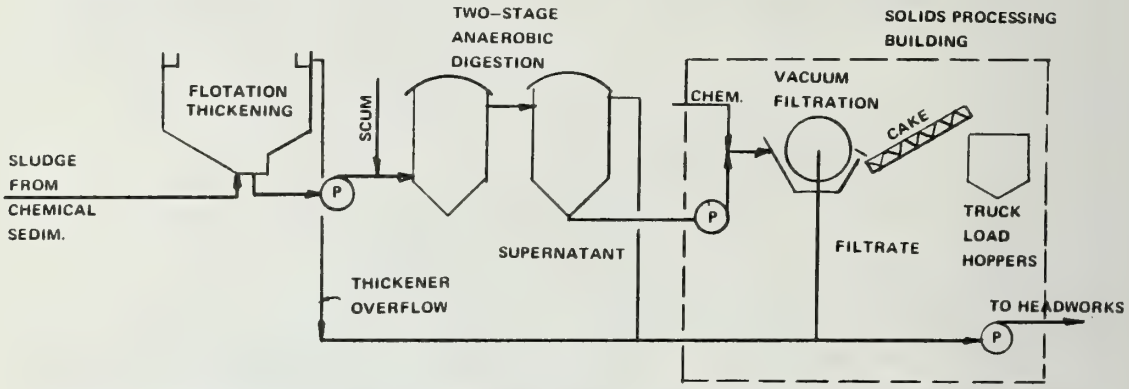
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–3, **B–4**, C–4

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING, ALUM

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flotation Thick. – 48 #/ft^2/day Digesters 0.1 # VSS/ft^3/day and 20 day detention vacuum filters 24 #/ft^2/day

NO. PROCESS UNITS: Float. Thick – 11; Digesters – 9; Vacuum Filters – 10

REDUNDANCY @ 100 MGD: One of each type (Thick. at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Flotation Thick. – 20'x40' (800 ft^2)
Digesters – 90' ϕ x 37' (236,000 ft^3)
Vacuum Filters – 12' ϕ x 24' (900 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 503
MAINTENANCE LABOR	151
POWER	374
FUEL	–
CHEMICALS	761
PARTS	240
SLUDGE HAUL	622
TOTAL ANNUAL O & M	2,651
CAPITAL COST	17,620

PRESENT VALUE OF COSTS:

O, M & R	25,190
CAPITAL	14,928
TOTAL	$40,118

FIGURE 8

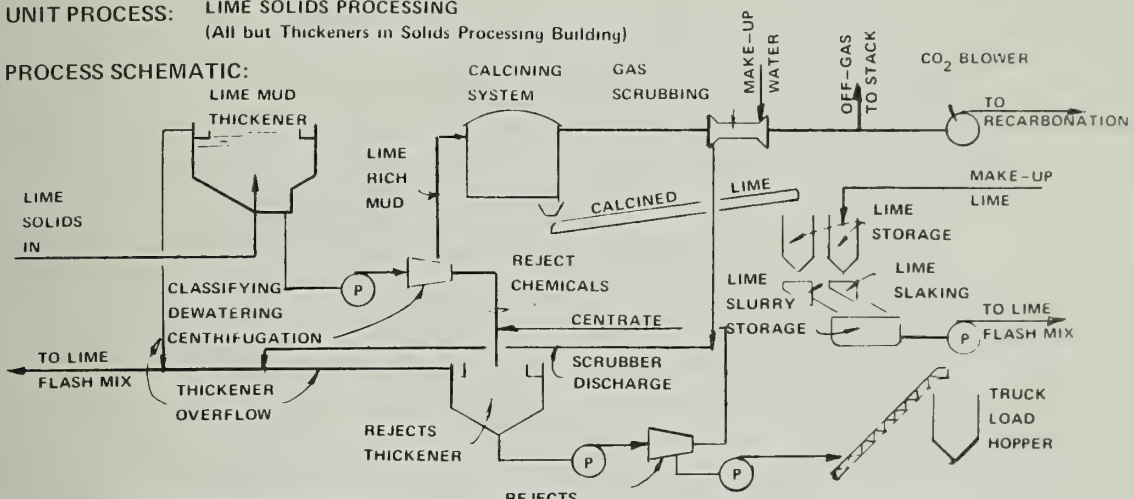
PROCESS UNIT DATA
INTERIM REPORT
COMBINED NORTH POINT AND
S.E. POINT TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–4, C–4

UNIT PROCESS: LIME SOLIDS PROCESSING
(All but Thickeners in Solids Processing Building)

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Lime Mud Thickeners and Solids Loading – 33 lbs/ft^2/day; Rejects Thickeners: Solids Loading – 32 lbs/ft^2/day; Calcining Furnaces: Output – 40 ton/day, each

NO. PROCESS UNITS: 5 Lime Mud Thickeners; 2 Rejects Thickeners; 1 Standby Thickener for both lime mud and rejects; 10 Classifying – Dewatering Centrifuges; 5 Fluidized Bed Furnaces; 9 Lime Storage Tanks; 6 Lime Slakers; 3 Slakers Lime Tanks; 10 Rejects Centrifuges; 8 CO_2 Compressor

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Lime Mud Thickeners – 90' diam.x 10', SWD, Rejects Thickeners – 90' diam. x 10' SWD, Classifying – Dewatering Centrifuges – 25"x90" Horiz. Solid Bowl; Lime Storage Tanks – 16' diam x 32' high; Lime Slakers – 4 at 10,000 lb/hr., 2 at 5,000 lbs/hr; Slaked Lime Tanks – 14' diam. x 11' deep; Rejects Centrifuges – 25" x60" Horiz. Solid Bowl CO_2 Compressors – 5 at 6,000 cfm, 3 at 3,000 cfm

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 305
MAINTENANCE LABOR	66
POWER	419
FUEL	339
CHEMICALS	181
PARTS	386
MISCELLANEOUS	
TOTAL ANNUAL O & M	1,696
CAPITAL COST	28,400

PRESENT VALUE OF COSTS:

O, M & R	16,115
CAPITAL	24,060
TOTAL	$40,175

FIGURE 9

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 3

MISCELLANEOUS OPERATING COSTS

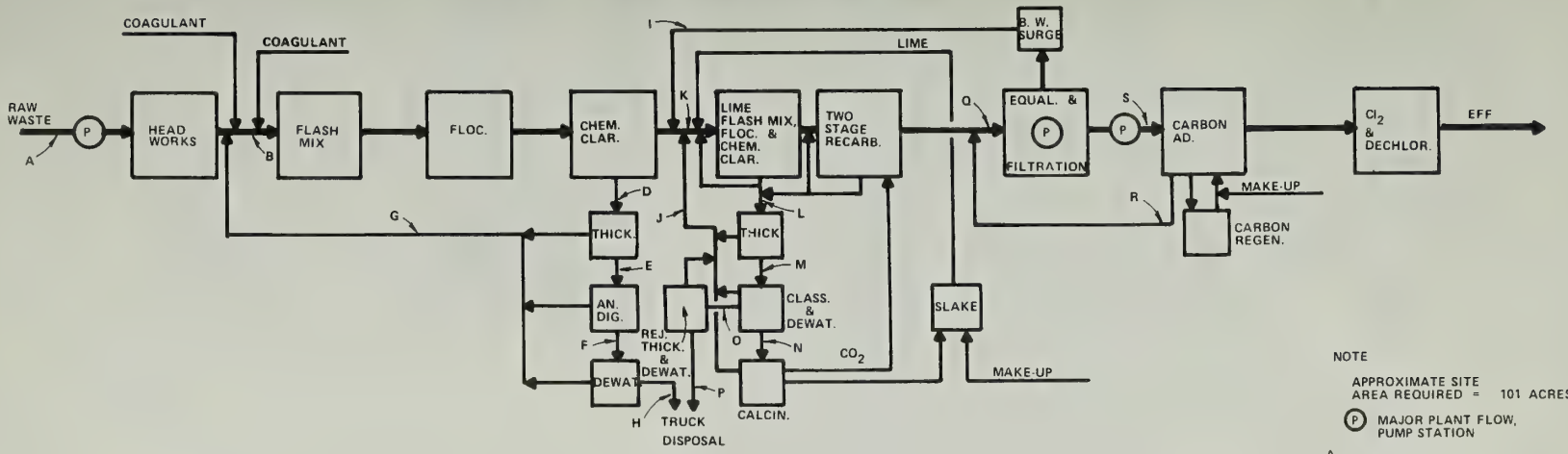
TREATMENT TRAIN: B-4 ALUM

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 174
CLERICAL	70
LABORATORY	108
YARD WORK	55
TOTAL ANNUAL COST	408
PRESENT VALUE	$3,873

TRAINS B-4F AND C-4F

TERTIARY PHYSICAL/CHEMICAL
FERRIC CHLORIDE - LIME

TREATMENT TRAINS B-4 AND C-4 // PHYSICAL - CHEMICAL TREATMENT FOR EPA & BAY DISCHARGE STANDARDS
– FERRIC CHLORIDE COAGULANT SYSTEM –



NOTE

APPROXIMATE SITE AREA REQUIRED = 101 ACRES

(P) MAJOR PLANT FLOW, PUMP STATION

A — POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Ave. Daily Flow Rate (mgd)	100	104 6	–	0 7	–	4.6	–	8	9 8	117 8	9 8	1.2	-	1 28	–	115	7	107
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	107 6		1 14		7 6	-	15	12 5	207 5	12 6	1 6	-	1 0		128	13	193
Ave. Daily BOD_5 (1000 lbs./day)	200						–	–	–		-	–		-	-	–	–	-
Peak 24hr. BOD_5 (1000 lbs./day)	346				-	–	–	–			-	–		–	-	–	–	–
Ave. Suspended Solids (1000 lbs./day)	167		233	233	181	45	136	5	-	-	820	820	570	250	320	–		
Peak 24hr. Suspended Solids (1000 lbs./day)	524		381	381				9	-		1050	1050	730	320	-	–		
Percent Solids			0 06	4	4		20				1	8	55	3	14	–	-	

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

B-4F-1

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN B-4F

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
		PRESENT VALUE OF COSTS[2]			
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$ 10,740
Chemical Treatment	11,240	3,040	9,520	28,910	38,430
Solids Disposal	15,710	2,390	13,310	22,710	36,020
Lime Treatment	14,970	1,460	12,680	13,890	26,570
Lime Recovery	28,400	1,700	24,060	16,120	40,180
Filtration	14,540	700	12,320	6,600	18,920
Carbon Adsorption and Regen.	26,850	2,430	22,750	23,130	45,880
Chlorination–Dechlorination	1,990	290	1,690	2,730	4,420
SUBTOTAL	$120,230	$12,560	$101,860	$119,300	$221,160
Ancillary Systems and Facilities[5]	18,220	410	15,440	3,880	19,320
TOTAL	$138,450	$12,970	$117,300	$123,180	$240,480

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

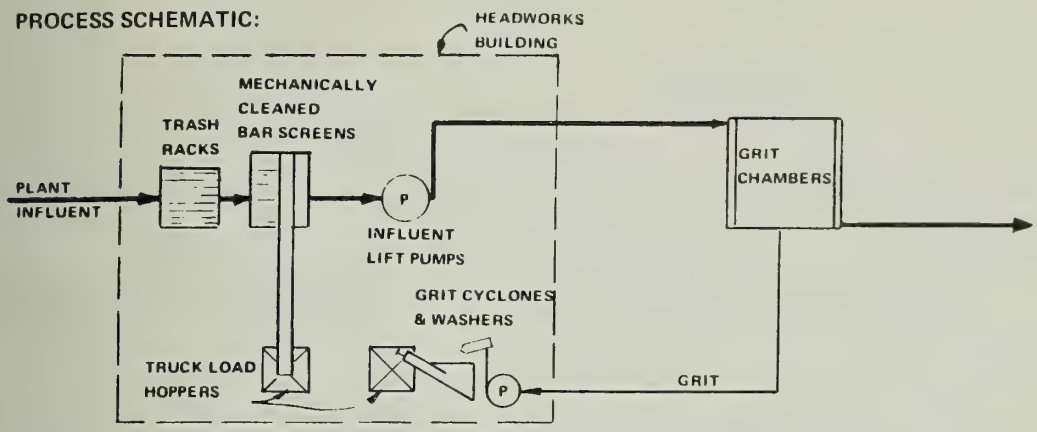
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, **B–4**, C–1, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548

CAPITAL COST 6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

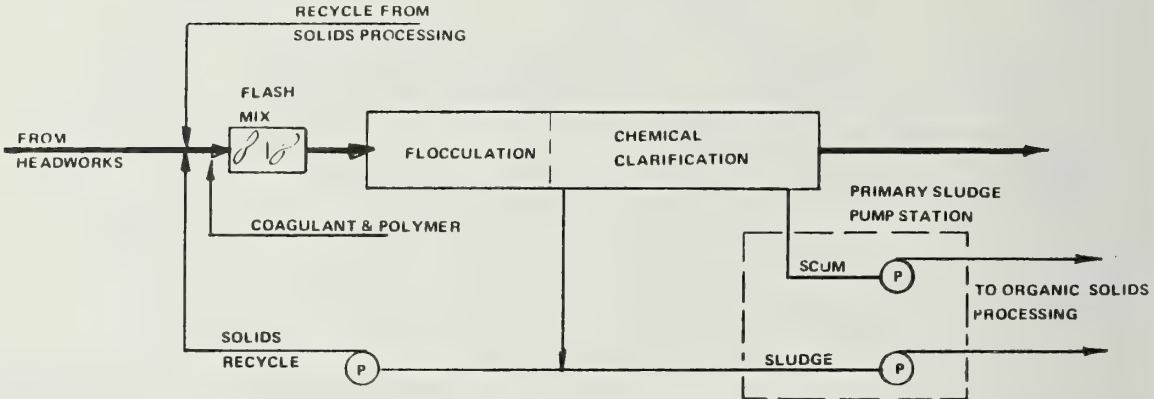
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–3, B–4, C–4

UNIT PROCESS: FLASH MIX, FLOCCULATION AND CHEMICAL CLARIFICATION, FERRIC CHLORIDE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flash Mix: 1.1 min. at 105 MGD, 0.6 Min. at 189 MGD, Flocculation: 14.8 min. at 105 MGD, 8.2 Min. at 189 MGD. Clarification: 555 gpd/ft^2 at 100 MGD, 1,000 gpd/ft^2 at 180 MGD

NO. PROCESS UNITS: Flash Mix: 3 Basins, Flocculation: 20 Basins, Clarification: 20 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix 20'x20'x9' SWD; Flocculation 20'x30'x12 SWD; Clarification: 300'x30'x 12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 263
MAINTENANCE LABOR	26
POWER	86
FUEL	–
CHEMICALS	2,626
PARTS	41
MISCELLANEOUS	–
TOTAL ANNUAL O & M	3,042
CAPITAL COST	11,240

PRESENT VALUE OF COSTS:

O, M & R	28,905
CAPITAL	9,520
TOTAL	$38,425

FIGURE 3

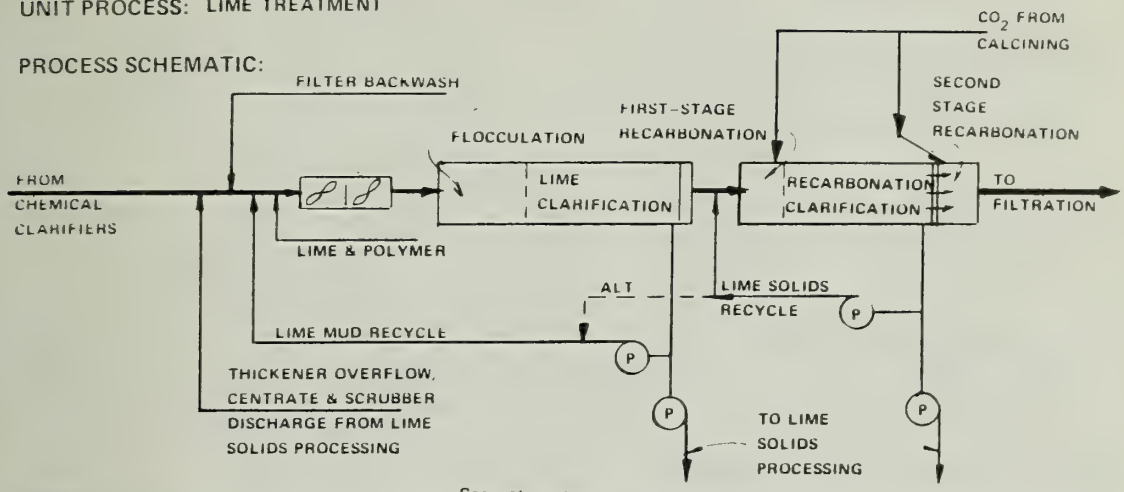
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B-4, C-4

UNIT PROCESS: LIME TREATMENT

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: See net page

NO. PROCESS UNITS: Flash Mix: 3 basins, Flocculation: 12 basins; Clarification: 12 basins; 1st Stage Recarbonation: 12 basins; Recarbonation Clarification: 12 basins; 2nd Stage Recarbonation: 12 basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Each Basin: Flash Mix – 20'x20'x12' SWD; Flocculation – 40'x30'x12' SWD; Clarification – 300'x30'x12' SWD; 1st Stage Recarbonation – 20'x30'x12' SWD; Recarbonation Clarification – 300'x30'x12' SWD 2nd Stage Recarbonation – 30'x21'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 93
MAINTENANCE LABOR	26
POWER	323
FUEL	–
CHEMICALS	960
PARTS	60
MISCELLANEOUS	–
TOTAL ANNUAL O & M	1,462
CAPITAL COST	14,971

PRESENT VALUE OF COSTS:

O, M & R	13,891
CAPITAL	12,683
TOTAL	$ 26,574

FIGURE 4

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

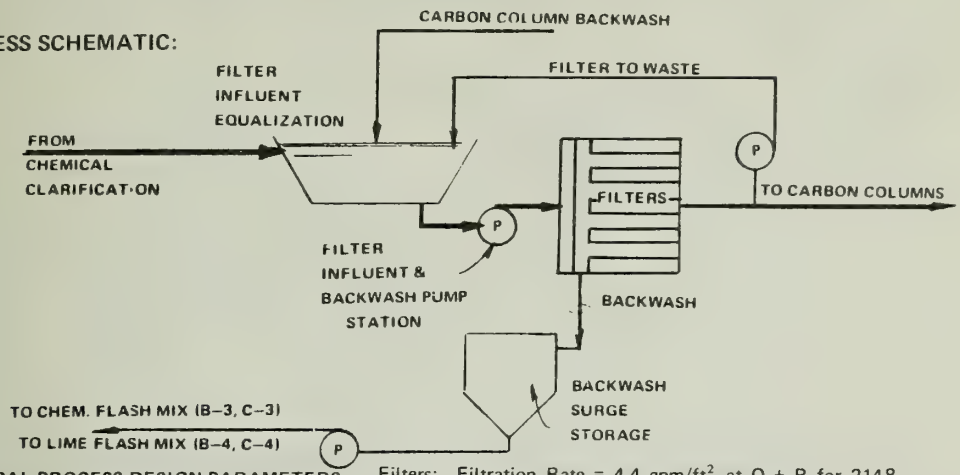
LIME TREATMENT

PARAMETER	AVERAGE DAY	MAXIMUM DAY
FLASH MIX		
Q + R, mgd	112	208
Detention Time, min.	1.4	0.8
FLOCCULATION		
Q + R, mgd	112	208
Detention Time, min.	16.6	9
CLARIFICATION		
Q + R – Sludge Drawoff, mgd	107	194
SOR, gpd/ft^2	990	1,800
1ST STAGE RECARBONATION		
Q + R, mgd	110	202
Detention Time, min.	9.3	5.1
RECARBONATION CLARIFICATION		
Q + R – Sludge Drawoff, mgd	108	194
SOR, gpd/ft^2	1,000	1,800
2ND STAGE RECARBONATION		
Q + R, mgd	108	194
Detention Time, min.	8.9	5

TREATMENT TRAIN: B-3, C-3, **B-4**, C-4

UNIT PROCESS: FILTRATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Filters: Filtration Rate = 4.4 gpm/ft^2 at Q + R for 214.8 2.5 gpm/ft^2 at Q + R for 121.3 MGD. Filter runs = 8 hrs. Backwash Rate = 20 gpm/ft^2, Surface Wash = 0.6 gpm/ft^2

NO. PROCESS UNITS: 36 Filters

REDUNDANCY @ 100 MGD: 1 Filter

INDIVIDUAL PROCESS UNIT SIZE: 32 ft. x 32 ft.

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 146
MAINTENANCE LABOR	68
POWER	183
FUEL	–
CHEMICALS	182
PARTS	116
MISCELLANEOUS	
TOTAL ANNUAL O & M	695

CAPITAL COST 14,540

PRESENT VALUE OF COSTS:

O, M & R	6,604
CAPITAL	12,318
TOTAL	$18,922

FIGURE 5

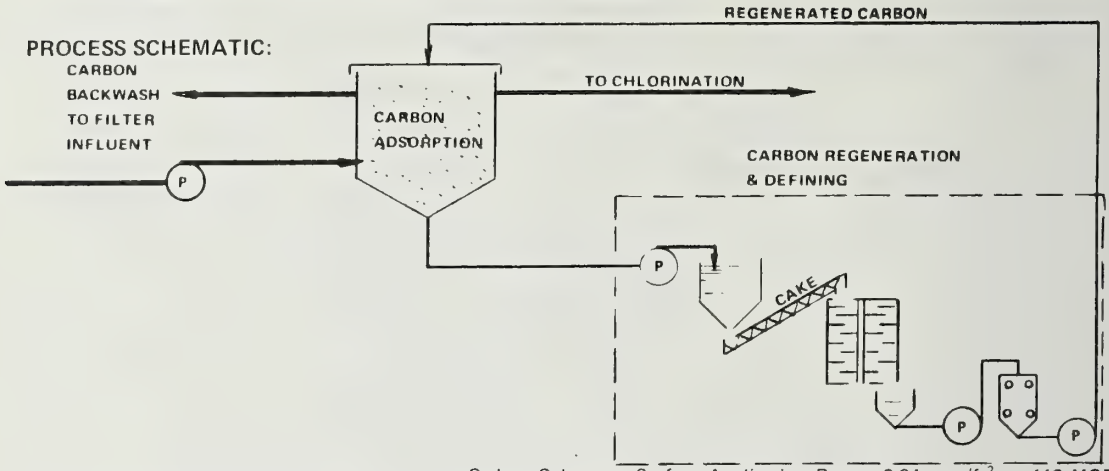
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B–3, **B–4**, C–3, C–4

UNIT PROCESS: CARBON TREATMENT & CARBON REGENERATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Carbon Columns: Surface Application Rate = 3.94 gpm/ft^2 at 113 MGD, Backwash Rate – 16 gpm/ft^2, Carbon Dose = 1,300 lbs/MG Contact Time = 36 min. Carbon Furnances: Hearth Loading – 41 lbs/ft^2/day at 100 MG

NO. PROCESS UNITS: 30 Columns; 3 Furnaces

REDUNDANCY @ 100 MGD:

INDIVIDUAL PROCESS UNIT SIZE: Carbon Columns – 26 ft. sq. x 18 ft. carbon depth
Carbon Furnaces – 22'-3" OD x 6 Hearth

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 249
MAINTENANCE LABOR	35
POWER	302
FUEL	165
CHEMICALS	1,549
PARTS	134
MISCELLANEOUS	
TOTAL ANNUAL O & M	2,434
CAPITAL COST	26,850

PRESENT VALUE OF COSTS:

O, M & R	23,128
CAPITAL	22,747
TOTAL	$45,875

FIGURE 6

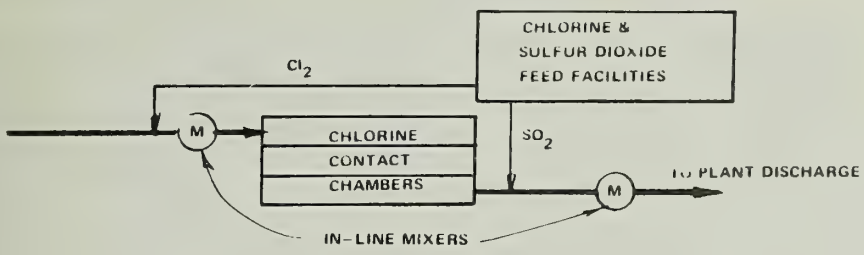
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, **B–4**, C–1, C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 7

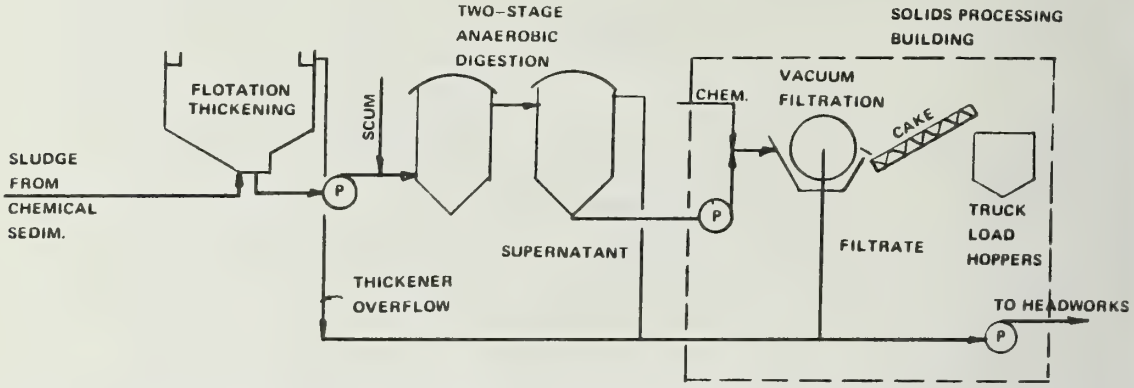
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–3, [B–4,] C–4

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING, FERRIC CHLORIDE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Flotation Thick. – 48 #/ft^2/day Digesters 0.1 # VSS/ft^3/day and 20 day detention vacuum filters 24 #/ft^2/day

NO. PROCESS UNITS: Float. Thick – 11; Digesters – 9; Vacuum Filters – 10

REDUNDANCY @ 100 MGD: One of each type (Thick. at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Flotation Thick. – 20'x40' (800 ft^2)
Digesters – 90' ϕ x 37' (236,000 ft^3)
Vacuum Filters – 12' ϕ x 24' (900 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 420
MAINTENANCE LABOR	101
POWER	276
FUEL	–
CHEMICALS	761
PARTS	210
SLUDGE HAUL	622
TOTAL ANNUAL O & M	2,390
CAPITAL COST	15,710

PRESENT VALUE OF COSTS:

O, M & R	22,710
CAPITAL	13,310
TOTAL	$36,020

FIGURE 8

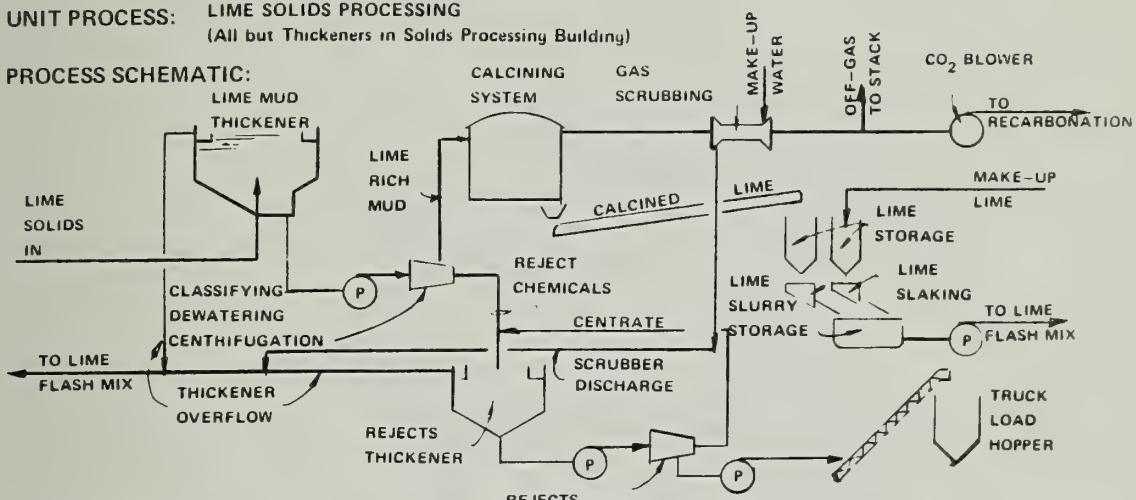
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: B-4, C-4

UNIT PROCESS: LIME SOLIDS PROCESSING
(All but Thickeners in Solids Processing Building)

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Lime Mud Thickeners and Solids Loading – 33 lbs/ft^2/day; Rejects Thickeners: Solids Loading – 32 lbs/ft^2/day; Calcining Furnaces: Output – 40 ton/day, each

NO. PROCESS UNITS: 5 Lime Mud Thickeners; 2 Rejects Thickeners; 1 Standby Thickener for both lime mud and rejects; 10 Classifying – Dewatering Centrifuges; 5 Fluidized Bed Furnaces; 9 Lime Storage Tanks; 6 Lime Slakers; 3 Slakers Lime Tanks; 10 Rejects Centrifuges; 8 CO_2 Compressor

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Lime Mud Thickeners – 90' diam. x 10' SWD, Rejects Thickeners – 90' diam. x 10' SWD, Classifying – Dewatering Centrifuges – 25"x90" Horiz. Solid Bowl; Lime Storage Tanks – 16' diam x 32' high; Lime Slakers – 4 at 10,000 lb/hr., 2 at 5,000 lbs/hr; Slaked Lime Tanks – 14' diam. x 11' deep; Rejects Centrifuges – 25" x60" Horiz. Solid Bowl CO_2 Compressors – 5 at 6,000 cfm, 3 at 3,000 cfm

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 305
MAINTENANCE LABOR	66
POWER	419
FUEL	339
CHEMICALS	181
PARTS	386
MISCELLANEOUS	
TOTAL ANNUAL O & M	1,696
CAPITAL COST	28,400

PRESENT VALUE OF COSTS:

O, M & R	16,115
CAPITAL	24,060
TOTAL	$40,175

FIGURE 9

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 3

MISCELLANEOUS OPERATING COSTS

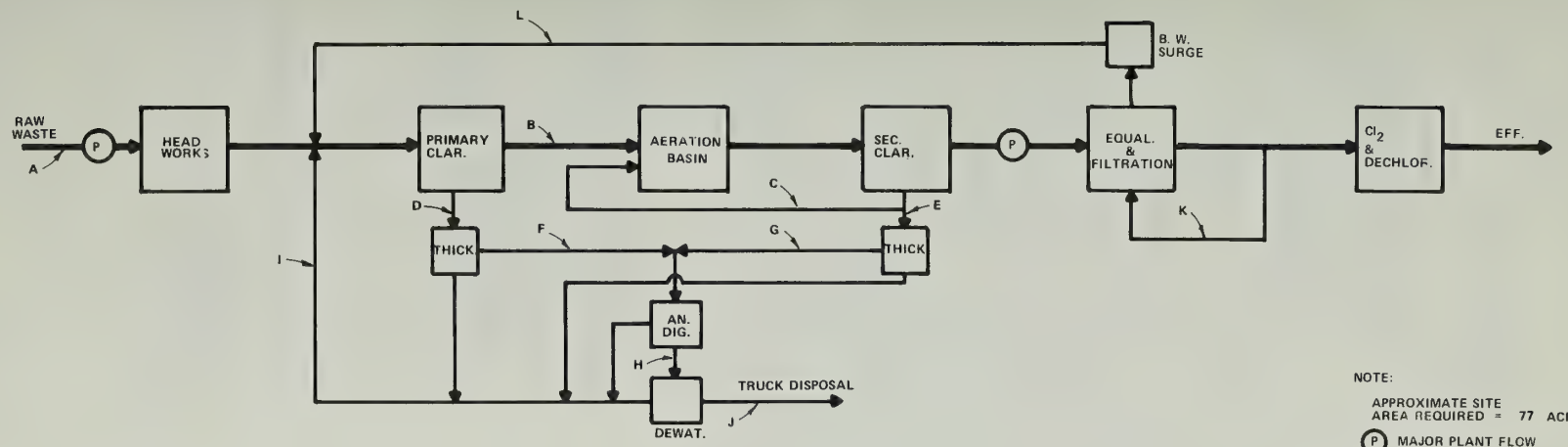
TREATMENT TRAIN: B-4 FERRIC CHLORIDE

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 174
CLERICAL	70
LABORATORY	108
YARD WORK	55
TOTAL ANNUAL COST	408
PRESENT VALUE	$3,873

TRAIN C-1

AIR ACTIVATED SLUDGE WITH FILTRATION

TREATMENT TRAIN C-1 // AIR ACTIVATED SLUDGE WITH AWT FOR BAY DISCHARGE STANDARDS



NOTE:

APPROXIMATE SITE AREA REQUIRED = 77 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A — POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B	C	D	E	F	G	H	I	J	K	L
Ave. Daily Flow Rate (mgd)	100		33			.21	24	-	2.2	–	8.9	8.9
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180	-	78			-			3.9	–	16	16
Ave. Daily BOD_5 (1000 lbs./day)	200	129							-	–		
Peak 24hr. BOD_5 (1000 lbs./day)	346	225				-		–		-		-
Ave. Suspended Solids (1000 lbs./day)	167			87	78	87	78	123	31	92	–	14
Peak 24hr. Suspended Solids (1000 lbs./day)	524			132	141	132	141		-	-		25
Percent Solids				3	0 5	5	4	5		22	-	

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN C-1

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$ 10,740
Primary Treatment	10,100	320	8,560	3,060	11,620
Air Activated Sludge	33,000	1,430	27,600	13,550	41,150
Post Chlorination and Dechlorination	1,990	290	1,690	2,730	4,420
Filtration	12,790	570	10,840	5,400	16,240
Solids Disposal	8,740	1,370	7,400	12,970	20,370
SUBTOTAL	$73,150	$4,530	$61,620	$42,920	$104,540
Ancillary Systems and Facilities[5]	8,950	390	7,580	3,720	11,300
TOTAL	$82,100	$4,920	$69,200	$46,640	$115,840

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

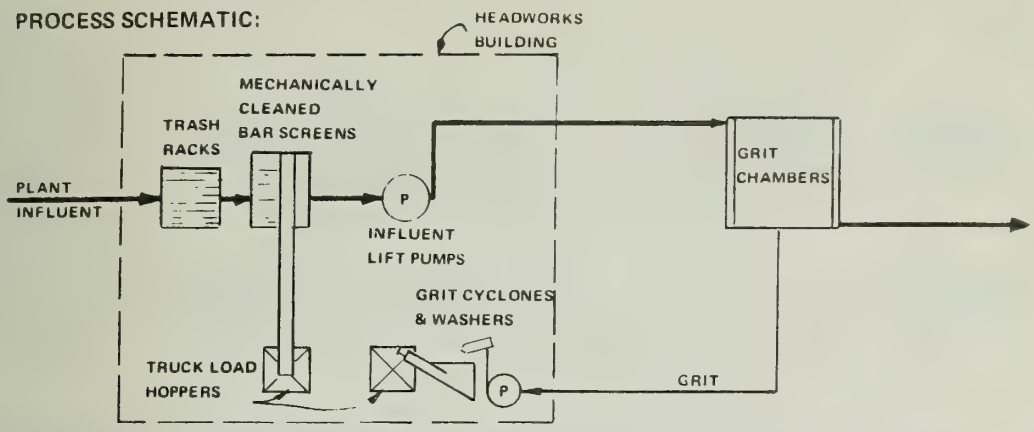
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, **C–1**, C–2, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530
PRESENT VALUE OF COSTS:	
O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

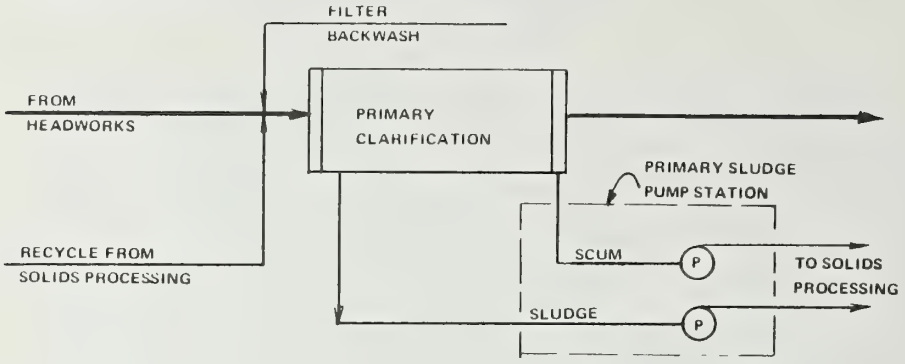
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C-1, C-2

UNIT PROCESS: PRIMARY TREATMENT

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Primary Clarifiers: 1,000 gpd/ft^2 at 180 MGD
SOR at Q+R for 108 MGD = 545 gpd/ft^2
SOR at Q+R for 196 MGD = 989 gpd/ft^2

NO. PROCESS UNITS: 22 Clarifiers

REDUNDANCY @ 100 MGD: 1 Clarifier

INDIVIDUAL PROCESS UNIT SIZE: 300'x30'x12 SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 239
MAINTENANCE LABOR	13
POWER	30
FUEL	–
CHEMICALS	–
PARTS	40
MISCELLANEOUS	–
TOTAL ANNUAL O & M	322
CAPITAL COST	10,099

PRESENT VALUE OF COSTS:

O, M & R	3,060
CAPITAL	8,556
TOTAL	$11,616

FIGURE 3

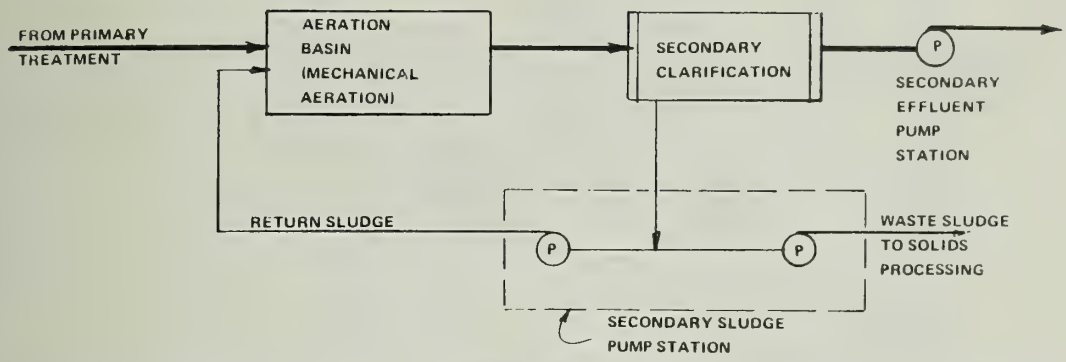
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C-1

UNIT PROCESS: AIR ACTIVATED SLUDGE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Aeration Basin Same as A-1, B-1 except Detention Time = 4 hr at 108 MGD, 7 hrs at 196 MGD

NO. PROCESS UNITS: 18 Aeration Basins 20 Clarifiers

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Aeration Basin: 116'x116'x18' SWD 4-75 HP Turbine Mixers per Basin Clarifier 325'x40'x15' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 347
MAINTENANCE LABOR	103
POWER	844
FUEL	–
CHEMICALS	–
PARTS	132
MISCELLANEOUS	–
TOTAL ANNUAL O & M	1,426
CAPITAL COST	33,000

PRESENT VALUE OF COSTS:

O, M & R	13,550
CAPITAL	27,598
TOTAL	$41,148

FIGURE 4

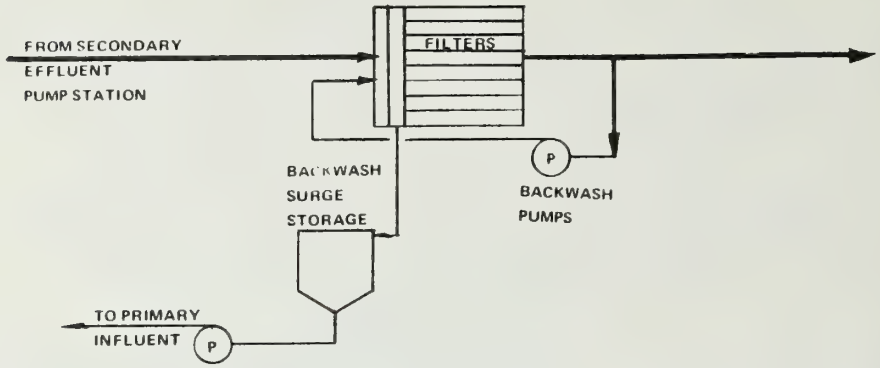
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: [C-1,] C-2

UNIT PROCESS: FILTRATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Filters: Filtration Rate = 4 gpm/ft^2 at Q+R for 196 MGD
2.05 gpm/ft^2 at Q + R for 106 MGD; Filter Runs = 8 hrs; Backwash Rate = 20 gpm/ft^2; Surface Wash Rate = 0.6 gpm/ft^2

NO. PROCESS UNITS: 36 Filters

REDUNDANCY @ 100 MGD: 1 Filters

INDIVIDUAL PROCESS UNIT SIZE: 32 ft. x 32 ft.

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 141
MAINTENANCE LABOR	70
POWER	73
FUEL	–
CHEMICALS	182
PARTS	102
MISCELLANEOUS	
TOTAL ANNUAL O & M	568
CAPITAL COST	12,790

PRESENT VALUE OF COSTS:

O, M & R	5,400
CAPITAL	10,840
TOTAL	$16,240

FIGURE 5

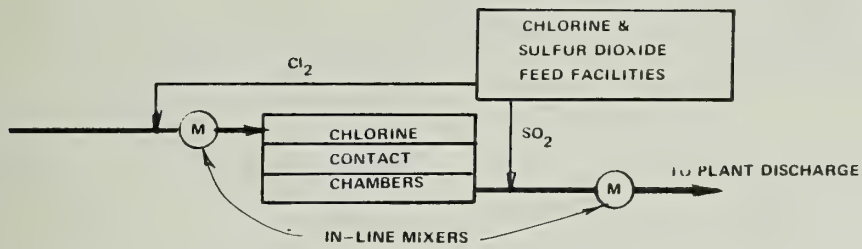
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, [C–1,] C–2, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287

CAPITAL COST 1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 6

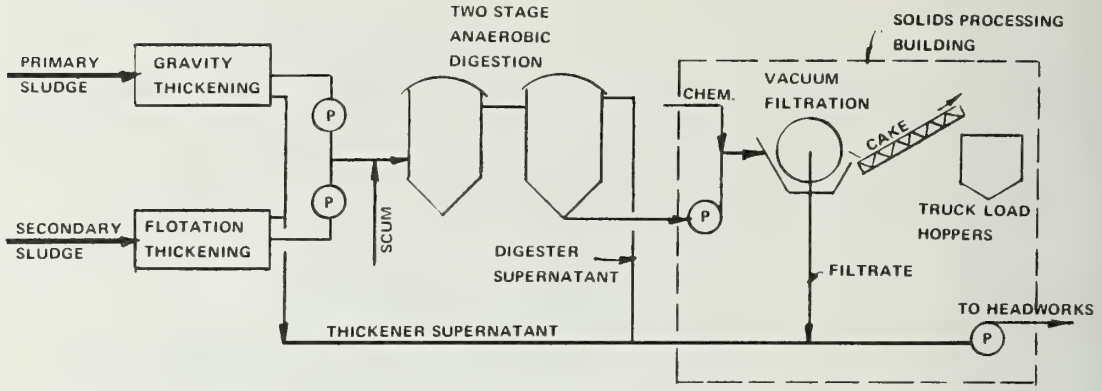
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C--1

UNIT PROCESS: ORGANICS SOLIDS THICKENING, DIGESTION & DEWATERING

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Gravity Thickening – 20 #/ft^2/day at 180 MGD; Flotation Thickening – 48 #/ft^2/day at 180 MGD; Digesters – 0.1 # VSS/ft^3/day and 20 day detention at 100 MGD; Vaccum Filters – 96 #/ft^2/day at 100 MGD

NO. PROCESS UNITS: Gravity Thickening – 3; Flotation Thickening – 5; Digesters – 5, Vaccum Filters – 3

REDUNDANCY @ 100 MGD: One of each type (Thickening at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Gravity Thickening – 65′ ϕ (3,320 ft^2); Flotation Thickening – 20′x38′ (760 ft^2); Digesters 95′ ϕ x 35′ (248,000 ft^2); Vacuum Filters – 12′ ϕ x 18′ (680 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 352
MAINTENANCE LABOR	101
POWER	137
FUEL	–
CHEMICALS	235
PARTS	119
SLUDGE HAUL	421
TOTAL ANNUAL O & M	1,365
CAPITAL COST	8,740

PRESENT VALUE OF COSTS:

O, M & R	12,970
CAPITAL	7,400
TOTAL	$20,370

FIGURE 7

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

MISCELLANEOUS OPERATING COSTS

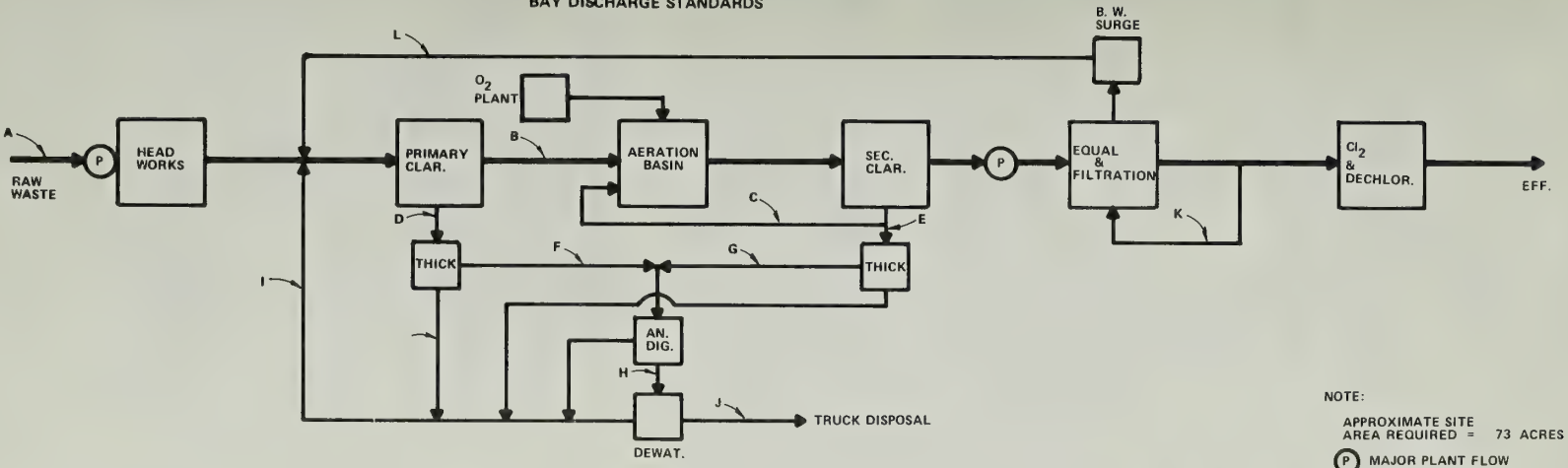
TREATMENT TRAIN: C-1

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 166
CLERICAL	67
LABORATORY	105
YARD WORK	53
TOTAL ANNUAL COST	392
PRESENT VALUE	$3,720

TRAIN C-2

HPO ACTIVATED SLUDGE WITH FILTRATION

TREATMENT TRAIN C-2 // HIGH PURITY OXYGEN ACTIVATED SLUDGE WITH AWT FOR BAY DISCHARGE STANDARDS



NOTE:

APPROXIMATE SITE AREA REQUIRED = 73 ACRES

(P) MAJOR PLANT FLOW PUMP STATION

A → POINT IN PROCESS (SEE TABLE BELOW)

POINTS IN PROCESS

DESIGN PARAMETERS	A	B	C	D	E	F	G	H	I	J	K	L
Ave. Daily Flow Rate (mgd)	100		33		–	22	20	-	1.02	–	8.9	8 9
Peak 72hr. Flow Rate & Peak Instantaneous Flow Rate (mgd)	180		78				-		1.74		16	16
Ave. Daily BOD_5 (1000 lbs./day)	200	129					-		-			
Peak 24hr. BOD_5 (1000 lbs./day)	346	225										
Ave. Suspended Solids (1000 lbs./day)	167			90	83	90	83	129	32	97		14
Peak 24hr. Suspended Solids (1000 lbs./day)	524			136	150	136	150					25
Percent Solids				3	1 5	5	5	5		22		

FIGURE 1

COMBINED NORTH POINT AND SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 1

SUMMARY OF ESTIMATED COSTS
TREATMENT TRAIN C-2

ITEM	ESTIMATED COSTS[1] (THOUSANDS OF DOLLARS)				
			PRESENT VALUE OF COSTS[2]		
	CAPITAL	O, M&R	CAPITAL[3]	O, M&R[4]	TOTAL
Headworks	$ 6,530	$ 550	$ 5,530	$ 5,210	$ 10,740
Primary Treatment	10,100	320	8,560	3,060	11,620
Oxygen Activated Sludge	28,680	1,150	27,250	10,880	38,130
Post Chlorination and Dechlorination	1,990	290	1,690	2,730	4,420
Filtration	12,790	570	10,840	5,400	16,240
Solids Disposal	7,870	1,290	6,670	12,300	18,970
SUBTOTAL	$67,960	$4,170	$60,540	$39,580	$100,120
Ancillary Systems and Facilities[5]	8,370	390	7,090	3,720	10,810
TOTAL	$76,330	$4,560	$67,630	$43,300	$110,930

(1) Order of magnitude level cost estimate.

(2) Present (January 1974) value of all costs through December 1997 at 5.625% annual discount rate.

(3) Expenditure schedule for capital costs assumed at 5% in 1974, 20% in 1975, 40% in 1976 and 35% in 1977.

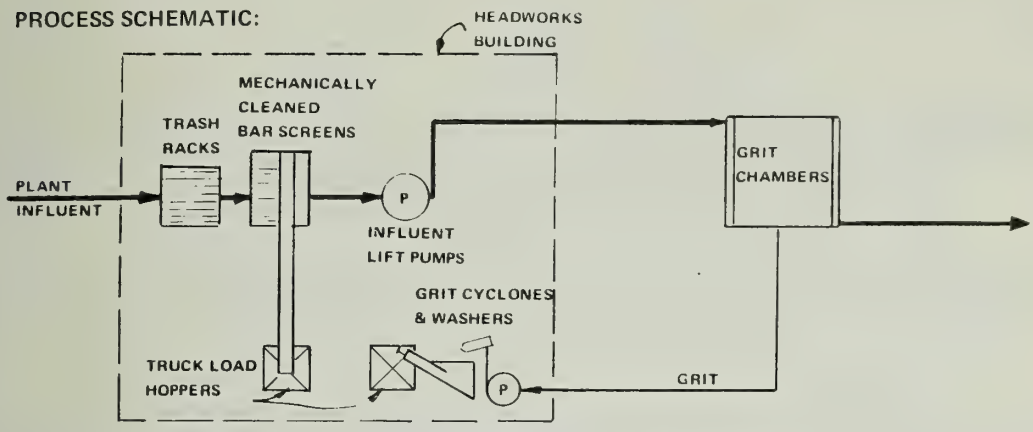
(4) At indicated constant annual rate of expenditure for 20 years (1978 through 1997).

(5) Systems and facilities to result in complete operating treatment plant, including but not limited to administration building, maintenance building, laboratories, piping, plumbing, electrical, instrumentation and control, site work and landscaping.

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, C–1, **C–2**, C–3, C–4

UNIT PROCESS: HEADWORKS

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Average Flow 100 MGD; Peak Flow 180 MGD for 24-72 hours duration; Minimum Flow 30 MGD Grit Chamber 12.6 min. at 100 MGD, 7 min. at 180 MGD

NO. PROCESS UNITS: 7 Trash Racks; 7 Bar Screens; 4-40 MGD Pumps and 2-30 MGD Pumps; 8 Grit Chambers; 8-Grit Washers and Cyclones

REDUNDANCY @ 100 MGD: One of each unit except pumps; 1-40 MGD Pump at 180 MGD

INDIVIDUAL PROCESS UNIT SIZE: Grit Chamber: 62'x62'x4' SWD each

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 278
MAINTENANCE LABOR	10
POWER	223
FUEL	–
CHEMICALS	–
PARTS	37
MISCELLANEOUS	
TOTAL ANNUAL O & M	548
CAPITAL COST	6,530

PRESENT VALUE OF COSTS:

O, M & R	5,210
CAPITAL	5,530
TOTAL	$10,740

FIGURE 2

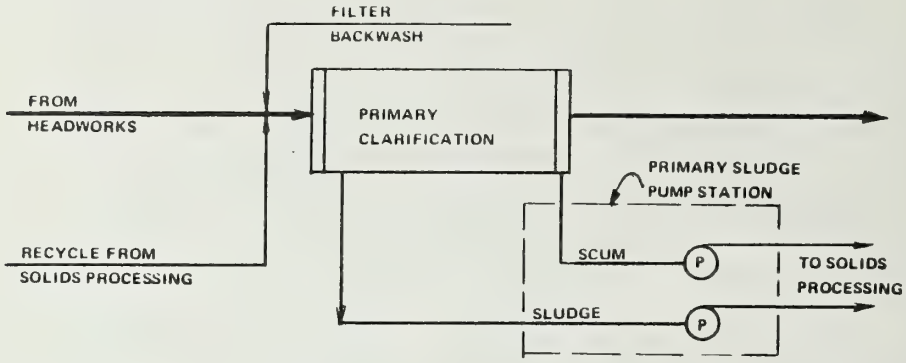
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C-1, C-2

UNIT PROCESS: PRIMARY TREATMENT

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Primary Clarifiers: 1,000 gpd/ft^2 at 180 MGD
SOR at Q+R for 108 MGD = 545 gpd/ft^2
SOR at Q+R for 196 MGD = 989 gpd/ft^2

NO. PROCESS UNITS: 22 Clarifiers

REDUNDANCY @ 100 MGD: 1 Clarifier

INDIVIDUAL PROCESS UNIT SIZE: 300'x30'x12 SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 239
MAINTENANCE LABOR	13
POWER	30
FUEL	–
CHEMICALS	–
PARTS	40
MISCELLANEOUS	–
TOTAL ANNUAL O & M	322

CAPITAL COST 10,099

PRESENT VALUE OF COSTS:

O, M & R	3,060
CAPITAL	8,556
TOTAL	$11,616

FIGURE 3

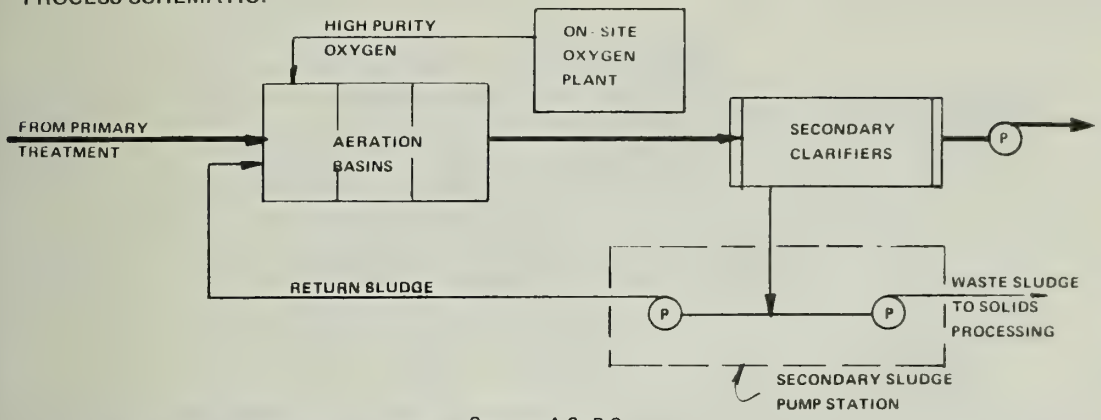
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C-2

UNIT PROCESS: HIGH PURITY OXYGEN – ACTIVATED SLUDGE

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Same as A-2, B-2

NO. PROCESS UNITS: Aeration Basin and Oxygen Generation Same as A-2, B-2. 16 Clarifier's

REDUNDANCY @ 100 MGD:

INDIVIDUAL PROCESS UNIT SIZE: Clarifier 325'x40'x15'SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 387
MAINTENANCE LABOR	118
POWER	525
FUEL	–
CHEMICALS	–
PARTS	115
MISCELLANEOUS	
TOTAL ANNUAL O & M	1,145
CAPITAL COST	28,675

PRESENT VALUE OF COSTS:

O, M & R	10,880
CAPITAL	27,247
TOTAL	$38,127

FIGURE 4

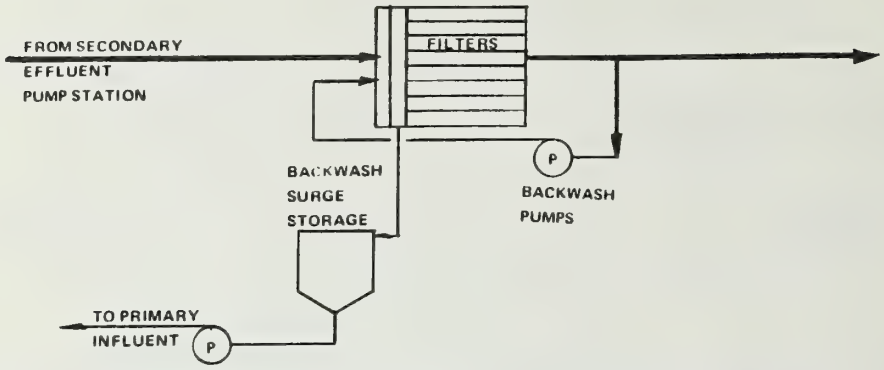
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C-1, C-2

UNIT PROCESS: FILTRATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Filters: Filtration Rate = 4 gpm/ft^2 at Q+R for 196 MGD 2.05 gpm/ft^2 at Q + R for 106 MGD; Filter Runs = 8 hrs; Backwash Rate = 20 gpm/ft^2; Surface Wash Rate = 0.6 gpm/ft^2

NO. PROCESS UNITS: 36 Filters

REDUNDANCY @ 100 MGD: 1 Filters

INDIVIDUAL PROCESS UNIT SIZE: 32 ft. x 32 ft.

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 141
MAINTENANCE LABOR	70
POWER	73
FUEL	–
CHEMICALS	182
PARTS	102
MISCELLANEOUS	
TOTAL ANNUAL O & M	568
CAPITAL COST	12,790

PRESENT VALUE OF COSTS:

O, M & R	5,400
CAPITAL	10,840
TOTAL	$16,240

FIGURE 5

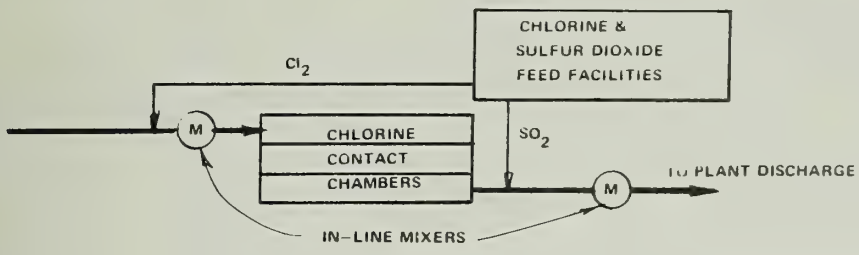
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: A–1, A–2, A–3, B–1, B–2, B–3, B–4, C–1, **C–2**, C–3, C–4

UNIT PROCESS: POST CHLORINATION AND DE–CHLORINATION

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Contact time: 23 min. at 180 MGD, 42 min. at 100 MGD

NO. PROCESS UNITS: 4 Basins

REDUNDANCY @ 100 MGD: 1

INDIVIDUAL PROCESS UNIT SIZE: Chlorine Contact Basin: 10'x 270'x12' SWD

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 20
MAINTENANCE LABOR	19
POWER	6
FUEL	–
CHEMICALS	234
PARTS	8
MISCELLANEOUS	
TOTAL ANNUAL O & M	287
CAPITAL COST	1,990

PRESENT VALUE OF COSTS:

O, M & R	2,730
CAPITAL	1,690
TOTAL	$4,420

FIGURE 6

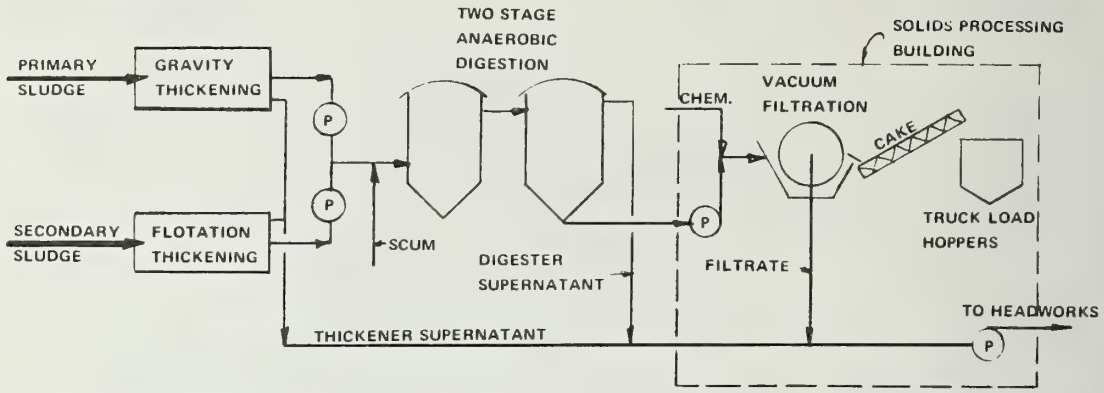
PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TREATMENT TRAIN: C-2

UNIT PROCESS: ORGANIC SOLIDS THICKENING, DIGESTION & DEWATERING

PROCESS SCHEMATIC:



PRINCIPAL PROCESS DESIGN PARAMETERS: Gravity Thickening – 20 #/ft^2/day at 180 MGD; Flotation Thickening – 48 #/ft^2/day at 180 MGD; Digesters – 0.1 # VSS/ft^2/day and 20 day detention at 100 MGD; Vacuum Filters – 96 #/ft^2/day at 100 MGD

NO. PROCESS UNITS: Gravity Thickening – 3; Flotation Thickening – 4; Digesters – 5; Vacuum Filters – 3

REDUNDANCY @ 100 MGD: One of each type (thickening at 180 MGD)

INDIVIDUAL PROCESS UNIT SIZE: Gravity Thickening – 65' ϕ (3,320 ft^2); Flotation Thickening – 20'x35' (700 ft^2) Digesters – 100' ϕ x 35' (274,000 ft^3); Vacuum Filters – 12' ϕ x 18' (680 ft^2)

ESTIMATE OF COST: (all costs in thousands of dollars)

ANNUAL O, M & R COST:

ANNUAL O, M & R COST:

OPERATIONS LABOR	$ 327
MAINTENANCE LABOR	94
POWER	124
FUEL	–
CHEMICALS	202
PARTS	107
SLUDGE HAUL	440
TOTAL ANNUAL O & M	1,294
CAPITAL COST	7,870

PRESENT VALUE OF COSTS:

O, M & R	12,295
CAPITAL	6,670
TOTAL	$18,965

FIGURE 7

PROCESS UNIT DATA
COMBINED NORTH POINT AND
SOUTHEAST TREATMENT PLANT

CITY AND COUNTY OF SAN FRANCISCO

TABLE 2

MISCELLANEOUS OPERATING COSTS

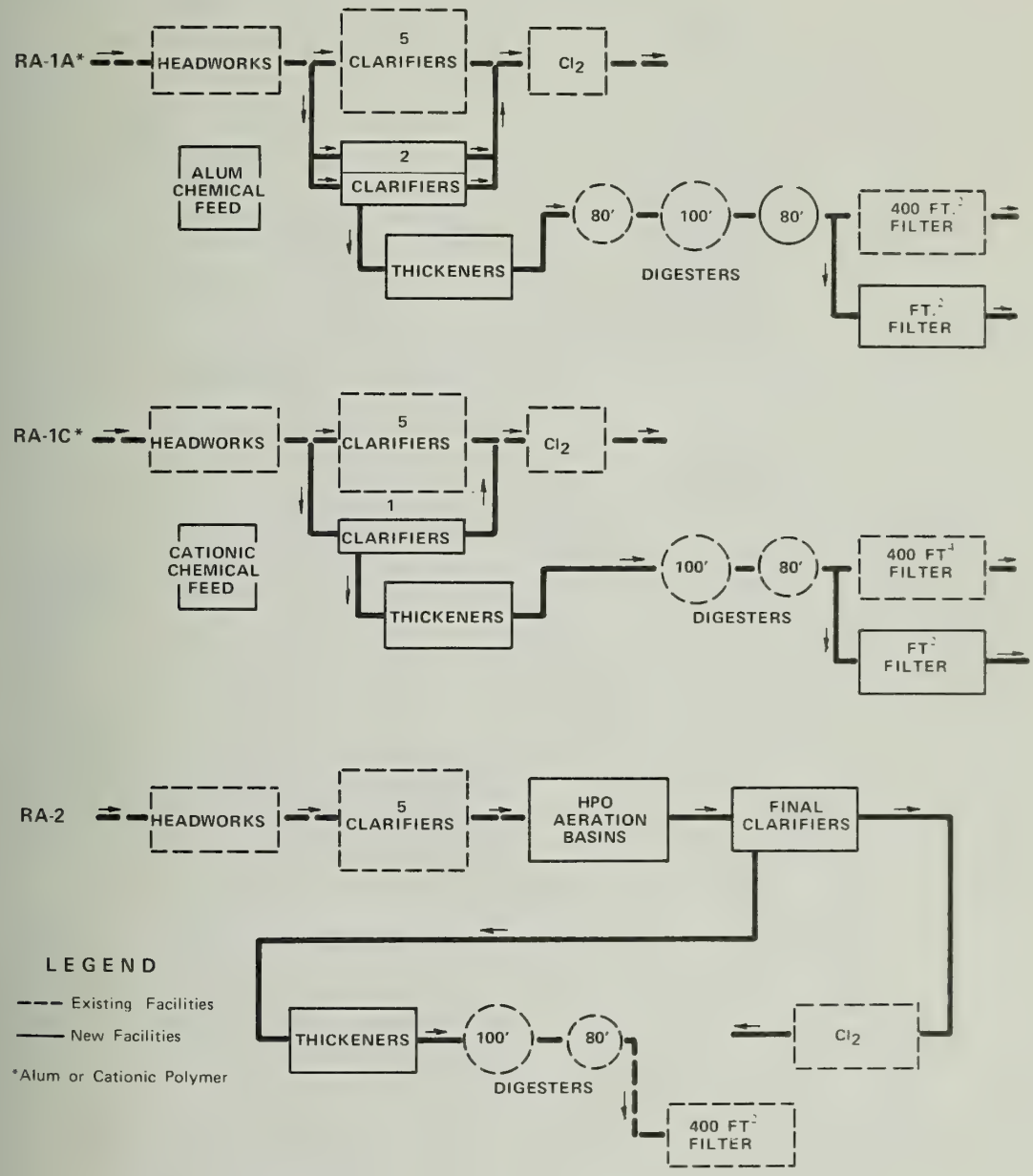
TREATMENT TRAIN: C-2

ITEM	ANNUAL COST THOUSANDS OF DOLLARS
SUPERVISORY	$ 166
CLERICAL	67
LABORATORY	105
YARD WORK	53
TOTAL ANNUAL COST	392
PRESENT VALUE	$3,720

RICHMOND-SUNSET

COST ESTIMATES

A. TRAINS TO MEET STATE OCEAN DISCHARGE STANDARDS



B. TRAINS TO MEET EPA STANDARDS

RB-1 SAME AS RA-2

RICHMOND–SUNSET
PROCESS TRAINS SELECTED FOR
ECONOMIC EVALUATION

RICHMOND - SUNSET
COST ESTIMATE SUMMARIES

TRAIN RS-A-3A

CAPITAL COST

Chemical Feed and Control		$ 280,000	
Clarifiers		455,000	
Sludge Thickeners		1,700,000	
Digester		595,000	
Miscellaneous		500,000	
		$4,849,000	
Engineering and Contingency 20%		970,000	
		$5,819,000	
Remodel Factor 15%		873,000	
	TOTAL	$6,692,000	
Present Value			$5,670,000

OM&R	HEADWORKS	PRIMARY	SOLIDS HANDLING	CHLORINATION
Operation Labor	90	82	163	7
Maintenance Labor	3	7	49	6
Power	8	13	121	2
Chemicals	–	580	166	76
Parts	12	–	78	3
Sludge Haul	–	–	183	–
TOTAL	113	704	760	94

OM&R PRESENT VALUE = $15,877,000

TOTAL PRESENT VALUE = $21,550,000

RICHMOND-SUNSET
COST ESTIMATE SUMMARIES (Cont'd)

TRAIN RS-A-3C

CAPITAL COST

Chemical Feed		$ 180,000	
Clarifier		277,000	
Vacuum Filter		1,100,000	
Thickeners		1,400,000	
Miscellaneous		500,000	
		$3,457,000	
Engineering and Contingency 20%		700,000	
		$4,200,000	
Remodel Factor 15%		630,000	
	TOTAL	$4,830,000	
Present Value			$4,092,000

OM&R	HEADWORKS	PRIMARY	SOLIDS HANDLING	CHLORINATION
Operation Labor	90	82	163	7
Maintenance Labor	3	7	49	6
Power	8	13	121	2
Chemicals	—	1775	126	76
Parts	12	12	70	3
Sludge Haul	—	—	137	—
TOTAL	113	1889	666	94

TOTAL OM&R = $2,762,000

PRESENT VALUE = $26,244,000

TOTAL PRESENT VALUE = $30,340,000

RICHMOND-SUNSET
COST ESTIMATE SUMMARIES (Cont'd)

TRAIN RS-A-2

CAPITAL COST		
Aeration Basins	$1,190,000	
Secondary Clarifiers	3,280,000	
Effluent Pump Station	360,000	
Cryo Building and Sludge Pump Station	671,000	
Primary Sludge Pump Station	270,000	
Thickeners		
Gravity	170,000	
Float	406,000	
Miscellaneous	1,555,000	
Oxygen Production and Dissolution	2,671,000	
	$10,573,000	
Engineering and Contingency 20%	2,115,000	
	$12,688,000	
Remodel Factor 15%	1,903,000	
TOTAL CAPITAL COST	$14,591,000	
PRESENT VALUE		$12,361,000

OM&R	HEADWORKS	PRIMARY	AERATION BASIN	SOLIDS HANDLING	CHLORINATION
Operation Labor	90	75	120	106	7
Maintenance Labor	3	4	38	30	6
Power	8	9	142	32	2
Chemicals	—	—	—	54	76
Parts	12	12	41	32	3
Sludge Haul	—	—	—	141	—
TOTAL	113	100	341	395	94

TOTAL OM&R = $9,910,000
PRESENT VALUE = $22,271,000

APPENDIX G

APPENDIX G

SAN FRANCISCO PILOT PLANT OPERATION MANUAL

	Page
Pilot Plant Description	G-1
Raw Sewage Pumping	G-8
Headworks	G-9
Train 1, Primary Clarifier	G-15
High Purity Oxygen Activated Sludge	G-17
Conventional Air Activated Sludge Process	G-19
Train 1, Physical/Chemical Processes	G-22
Filtration	G-24
Activated Carbon Adsorption	G-30
Train 2, Two-Stage Physical/Chemical Treatment of Raw Sewage	G-39
High Lime Coagulation and Clarification	G-40
Two-Stage Recarbonation	G-43
Train 3, Physical/Chemical Process	G-45
Chemical Mixing and Addition	G-46
Equipment Maintenance and Description Manual	G-50

Attachments:

1 Chemical Solution Preparation
2 A/S Loading
3 List of Chemical Suppliers
4 Miscellaneous Flow Graphs
5 Calgon Pilot Filtrasorb System Instruction Manual

APPENDIX G

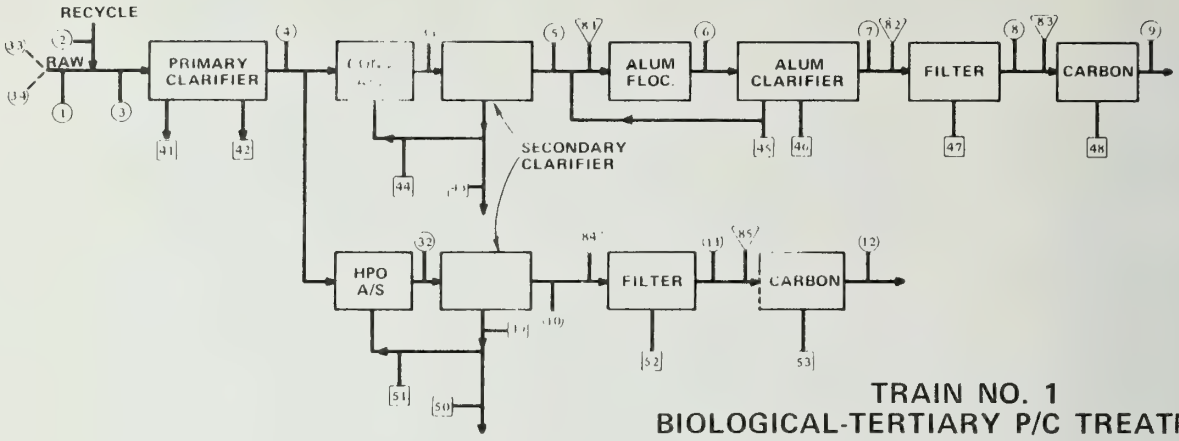
SAN FRANCISCO PILOT PLANT OPERATING MANUAL

PILOT PLANT DESCRIPTION

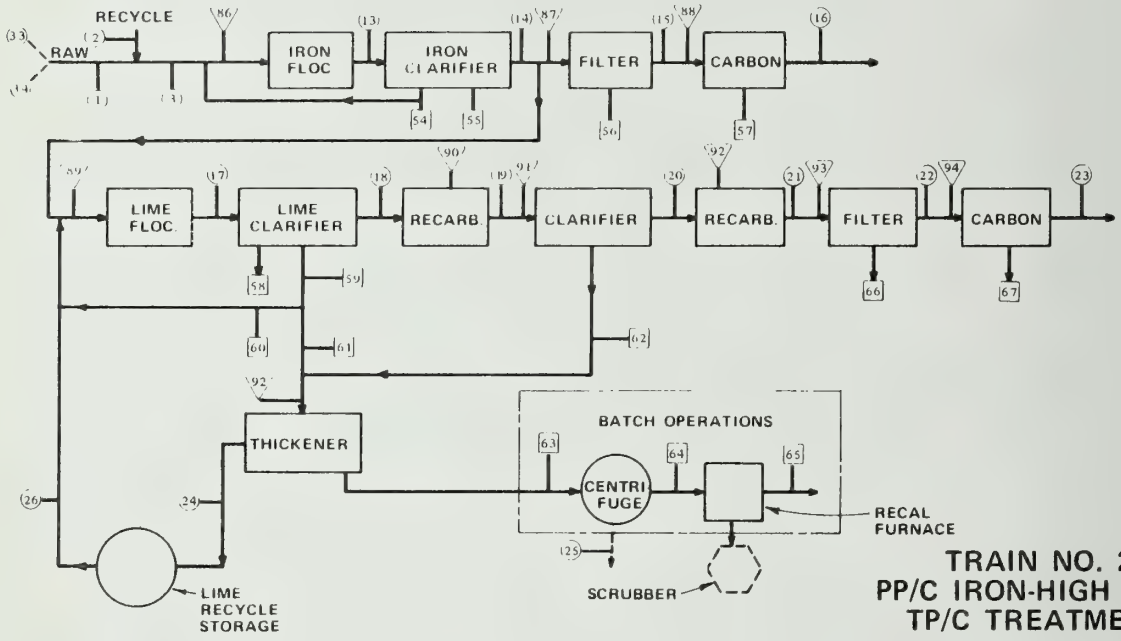
The process flow sheet for the pilot plant is shown on Figure G-1. The pilot plant is divided into three process trains which eventually produce five different effluents. The design criteria, detention times, capabilities, et cetera are shown on Figures G-2 thru G-6.

Train 1 consists of a raw sewage influent, primary treatment, and equal division of the primary effluent to a conventional complete-mix and high purity oxygen activated sludge process. The secondary clarifier effluents of the activated sludge processes can be processed two ways. One is directed to physical/chemical treatment with chemical coagulation and clarification followed by filtration and activated carbon adsorption. The other biological effluent is processed only by filtration and activated carbon adsorption. Train 2 consists of a raw sewage influent followed by a high ferric chloride coagulation and clarification process, the effluent of which is divided into two portions. One part is processed by direct filtration and activated carbon, while the other is directed to a high lime coagulation and clarification process. The high lime effluent is passed through a dual stage recarbonation process followed by filtration and activated carbon.

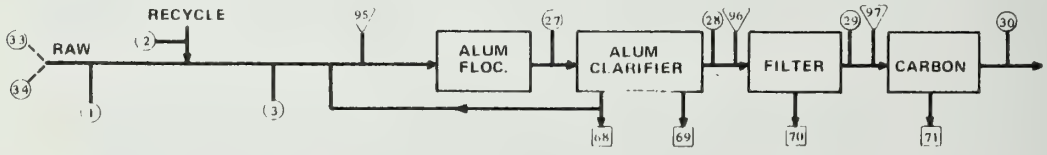
Train 3 consists of a raw sewage influent with chemical coagulation and clarification followed by direct filtration and clarification followed by direct filtration and activated



TRAIN NO. 1
BIOLOGICAL-TERTIARY P/C TREATMENT



TRAIN NO. 2
PP/C IRON-HIGH LIME
TP/C TREATMENT



TRAIN NO. 3
TERTIARY PHYSICAL/CHEMICAL TREATMENT

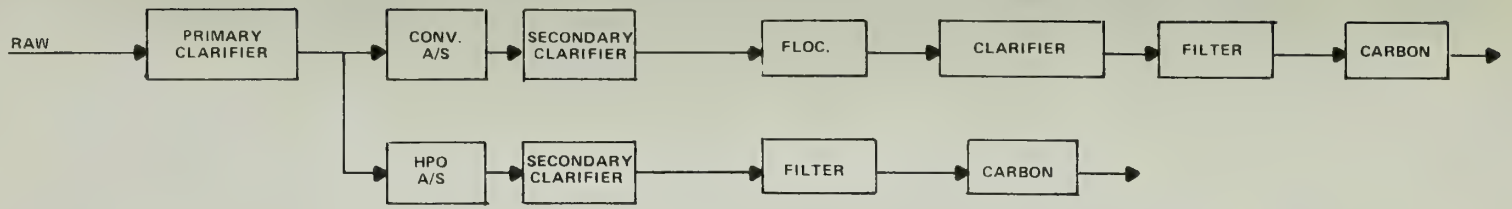
NOTES:

(1)	TO (34)	LIQUID STREAM DATA POINTS
[41]	TO [71]	SOLID OR WASTE DATA POINTS
⟨81⟩	TO ⟨97⟩	CHEMICAL ADDITION POINTS
– – – –		INDICATES NP + SE
(33)		SE RAW
(34)		NP RAW

FIGURE G-1

SOUTHEAST PILOT PLANT
PROCESS TRAINS AND DATA COLLECTION POINTS

TRAIN NO. 1 BIOLOGICAL – TERTIARY P/C TREATMENT



DESIGN CRITERIA	CONVENTIONAL PRIMARY				CONVENTIONAL ACT. SLUDGE			HPO ACT. SLUDGE			SECONDARY CLARIFIERS			RAPID MIX			
DIAMETER, FT [2]	9				–			–			6			–			
SWD [3] DEPTH, FT.	8.83				8'			5.2			3.33			–			
LIQUID DEPTH, FT	10.0				8'			5.2			9.50						
SURFACE AREA, SF [2]	63.78				–			–			28.6			–			
VOLUME, GAL.	5044 [4]				4338			1600			2376			13.4			
STAGE VOLUME, GAL.	–				–			400			–			–			
TYPE	CONVENTIONAL				COMPLETE MIX AIR			OXYGEN			CONVENTIONAL			–			
EFF BED DEPTH, FT	–				–			–			–			–			
CARBON, LBS.	–				–			–			–			–			
PERCENT OF DESIGN	75	100	150	MAX.	75	100	150	75	100	150	75	100	150	75	100	150	MAX.
FLOW, GPM	33	44.2	66.3	79.5	10.3	13.8	20.7	10.3	13.7	20.5	10.2	13.6	20.4	6.6	8.9	13.4	16
DETENTION TIME, HRS.	2.5	1.9	1.3	1.1	6.9 [5]	5.2 [5]	3.5 [5]	2.6 [5]	1.9 [5]	1.3 [5]	3.9	2.9	1.9	2	1.5	1	.8
OVERFLOW, GPD/SF	750	1000	1500	1795		–	–		–	–	514	684	1027				–
HYDRAULIC LOADING, GPM/SF	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–
VELOCITY, FPM	–	–	–	–	–	–	–	–	–		–	–			–	–	
MIXING FORCE, G, FPS/F	–	–	–	–	–	–	–		–		–	–		300	300	300	300
CONTACT TIME, MIN	–	–	–		–	–		–	–	–	–	–		–	–		–

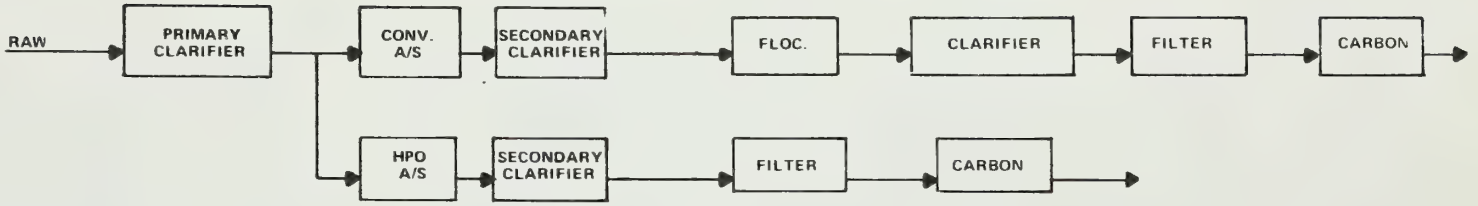
(1) MINUTES
(2) EFFECTIVE DIAMETER OR AREA (DEDUCTS AREA OCCUPIED BY CLARIFIER FEED WELL AND LAUNDER)
(3) SIDE WATER DEPTH
(4) SIDE WATER VOLUME MINUS FEED WELL
(5) BASED ON Q

METRIC FORMULAS

FT	= (x 0.3048 m)		GPD/SF	= (x 0.0408 $m^3/m^2/d$)	
SF	= (x 0.0929 sq.m.)		GPM/SF	= (x 40.7 l/min/spm)	
GAL	= (x 3.785 l)		FPM	= (x 0.03048 m/min)	
LBS	= (x 6.454 kg)		FPS/F	= (x 1.0 m/sec/m)	
GPM	= (x 0.0631 l/s)				

FIGURE G-2

TRAIN NO. 1 BIOLOGICAL – TERTIARY P/C TREATMENT



DESIGN CRITERIA	FLOCCULATION				CHEMICAL CLARIFIER				FILTER			CARBON		
DIAMETER, FT	–				3.98[2]				0.46			0.417		
SWD[3] DEPTH, FT.	-				8.83				–			-		
LIQUID DEPTH, FT					9.33				–			–		
SURFACE AREA, SF	–				12.41[2]				0.165			0.14		
VOLUME, GAL.	56 TO 352				1132				-			15.7		
STAGE VOLUME, GAL	–				–				–			3.9		
TYPE	-				CONVENTIONAL				DUAL MEDIA			DOWN FLOW		
EFF BED DEPTH, FT	–				-				2.5' A, .5' S			15		
CARBON, LBS	–				–				–			61.7[5]		
PERCENT OF DESIGN	75	100	150	MAX.	75	100	150	MAX.	75	100	150	75	100	150
FLOW, GPM	6.6	8.9	13.4	16.0	6.5	8 7	13 1	15.7	.5	.66	1.0	.31	.42	.64
DETENTION TIME, HRS.	22[1]	16.5[1]	11[1]	8.6[1]	2.9	2.2	1.4	1.2		–	–	–	–	
OVERFLOW, GPD/SF	–	–	-	–	754	1009	1520	1821	–	–	–	–	--	
HYDRAULIC LOADING, GPM/SF	-	-	–	–	–	–	–	–	3	4	6	2.3	3 1	4 65
VELOCITY, FPM	-		–	–	–	–	-	–	–	-	-	-	-	
MIXING FORCE, G, FPS/F	45	45	45	45	–	–	-	–	-	-	-	-	--	
CONTACT TIME, MIN.	–	–	–	-	–	–	–	–	–	–	–	50[5]	36[5]	18[6]

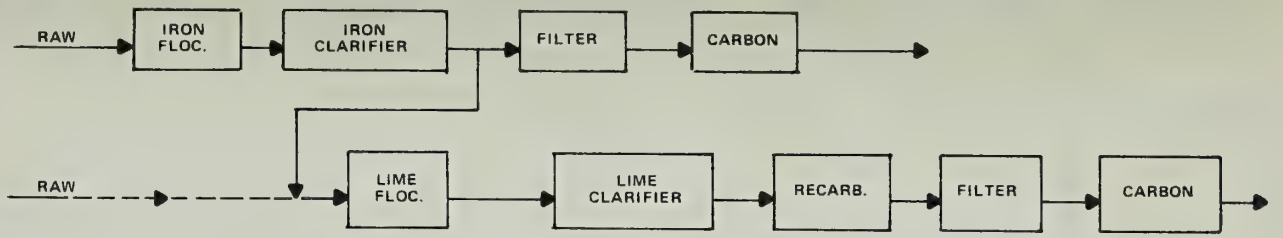
(1) MINUTES
(2) EFFECTIVE DIAMETER OR AREA (DEDUCTS AREA OCCUPIED BY CLARIFIER FEED WELL AND LAUNDER)
(3) SIDE WATER DEPTH
(4) SIDE WATER VOLUME MINUS FEED WELL
(5) 4 - 3.75' EFFECTIVE DEPTH COLUMNS
(6) 3 – 3.75' EFFECTIVE DEPTH COLUMNS

METRIC FORMULAS

FT	= (x 0.3048 m)		GPD/SF	= (x 0.0408 $m^3/m^2/d$)	
SF	= (x 0.0929 sq.m.)		GPM/SF	= (x 40.7	min/spm)
GAL	= (x 3.785 l)		FPM	= (x 0.03048 m/min)	
LBS	= (x 6.454 kg)		FPS/F	= (x 1.0 m/sec/m)	
GPM	= (x 0.0631 l/s)				

FIGURE G-3

TRAIN NO. 2 FERRIC CHLORIDE TP/C AND FERRIC CHLORIDE PP/C – LIME TP/C TREATMENT



DESIGN CRITERIA	IRON RAPID MIX				IRON FLOCCULATION				IRON CLARIFIER				LIME RAPID MIX				LIME FLOCCULATION			
DIAMETER, FT.	–				–				9[2]				–				–			
SWD[3] DEPTH, FT.	–				–				8.83				–				–			
LIQUID DEPTH, FT.	–				–				10.0				–				–			
SURFACE AREA, SF	–				–				63.78[2]				–				–			
VOLUME, GAL.	69				313 – 1,806				5,044[4]				21.4				88.8 – 627			
STAGE VOLUME, GAL.	–				–				–				–				–			
TYPE	–				–				CONVENTIONAL				MECHANICAL MIX				MECHANICAL MIX			
EFF BED DEPTH, FT.	–				–				–				–				–			
CARBON, LBS	–				–				–				–				–			
PERCENT OF DESIGN	75	100	150	MAX.	75	100	150	MAX.	75	100	150	MAX.	75	100	150	MAX.	75	100	150	MAX.
FLOW, GPM	34	45.6	69	82.1	34	45.6	69	82.1	33	44.2	66.3	79.5	10.7	14.3	21.4	28.5	10.7	14.3	21.4	28.5
DETENTION TIME, HRS	2.0[1]	1.5[1]	1[1]	0.8[1]	22[1]	16.5[1]	11[1]	9.2[1]	2.5	1.9	1.3	1.1	2.0[1]	1.5[1]	1.0[1]	0.8	22[1]	16.5[1]	11[1]	8.8
OVERFLOW, GPD/SF	–	–	–	–	–	–	–	–	750	1000	1500	1795	–	–	–		–	–	–	
HYDRAULIC LOADING, GPM/SF	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
VELOCITY, FPM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MIXING FORCE, G, FPS/F	300	300	300	300	45	45	45	45	–	–	–	–	300	300	300	300	45	45	45	45
CONTACT TIME, MIN	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–

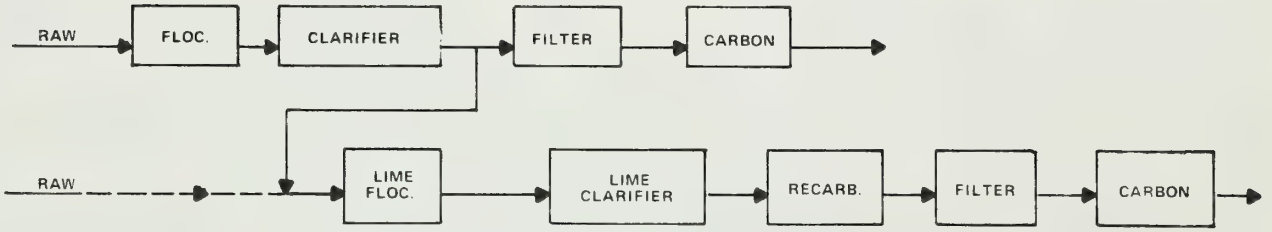
(1) MINUTES
(2) EFFECTIVE DIAMETER OR AREA (DEDUCTS AREA OCCUPIED BY CLARIFIER FEED WELL AND LAUNDER)
(3) SIDE WATER DEPTH
(4) SIDE WATER VOLUME – MINUS FEED WELL
(5) 4 - 3.75' EFFECTIVE DEPTH COLUMNS
(6) 3 3.75' EFFECTIVE DEPTH COLUMNS

METRIC FORMULAS

FT	=	(x 0.3048 m)	GPD/SF	=	(x 0.0408 $m^3/m^2/d$)
SF	=	(x 0.0929 sq.m.)	GPM/SF	=	(x 40.7 l/min/spm)
GAL	=	(x 3.785 l)	FPM	=	(x 0.03048 m/min)
LBS	=	(x 6.454 kg)	FPS/F	=	(x 1.0 m/sec/m)
GPM	=	(x 0.0631 l/s)			

FIGURE G-4

TRAIN NO. 2 LOW IRON – HIGH LIME P/C TREATMENT



DESIGN CRITERIA	LIME CLARIFIER	1ST STAGE RECARBONATION	RECARBONATION CLARIFIER	2ND STAGE RECARBONATION	FILTER	CARBON
DIAMETER, FT	4.9[2]	–	2.9[2]	–	0.46	0.417
SWD[3] DEPTH, FT	8.83	–	5.08	–	–	–
LIQUID DEPTH, FT	9.50	–	5.5	–	–	–
SURFACE AREA, SF	19.0[2]	–	6.64[2]		0.165	0.14
VOLUME, GAL	1647[4]	90.7	385[4]	88.5	–	15.7
STAGE VOLUME, GAL.	–	–	–	–	–	3.9
TYPE	CONVENTIONAL	CO_2 DIFFUSER	CONVENTIONAL	CO_2 DIFFUSER	DUAL MEDIA	DOWN FLOW
EFF. BED DEPTH, FT	–	–	–	–	2.5' A. .5' S	15
CARBON, LBS	–	–	–	–	–	61.7[5]

PERCENT OF DESIGN	75	100	150	MAX.	75	100	150	75	100	150	75	100	150	75	100	150	75	100	150
FLOW, GPM	10.2	13.6	20.4	27.2	6.0	8.1	12.1	5.9	7.9	11.8	5.9	7.9	11.8	.5	.66	1.0	.31	.42	.64
DETENTION TIME, HRS.	2.7	2	1.3	1.0	15[1]	11.2[1]	7.5[1]	1.1	0.8	0.5	15[1]	11.2[1]	7.5[1]	-	-	–	–	–	–
OVERFLOW, GPD/SF	773	1031	1546	2061	–	–	–	1280	1713	2560	–	–	–	–	–	–	–	–	–
HYDRAULIC LEADING, GPM/SF	–	–	–	–	–	–	–	–	–	–	–	–	–	3	4	6	2.3	3.1	4.65
VELOCITY, FPM	–	–	–	–	–	–	–	–	–	–	–	–	–	-	-	-	-	-	–
MIXING FORCE, G, FPS/F	–	–	–	–	–	–	–	–	–	–	–	–	–	-	-	-	–	–	–
CONTACT TIME, MIN.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	50[5]	36[5]	18[6]

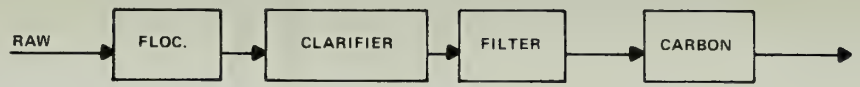
(1) MINUTES
(2) EFFECTIVE DIAMETER OR AREA (DEDUCTS AREA OCCUPIED BY CLARIFIER FEED WELL AND LAUNDER)
(3) SIDE WATER DEPTH
(4) SIDE WATER VOLUME – MINUS FEED WELL
(5) 4 – 3.75' EFFECTIVE DEPTH COLUMNS
(6) 3 – 3.75' EFFECTIVE DEPTH COLUMNS

METRIC FORMULAS

FT	= (x 0.3048 m)		GPD/SF	= (x 0.0408 $m^3/m^2/d$)	
SF	= (x 0.0929 sq.m.)		GPM/SF	= (x 40.7 l/min/spm)	
GAL	= (x 3.785 l)		FPM	= (x 0.03048 m/min)	
LBS	= (x 6.454 kg)		FPS/F	= (x 1.0 m/sec/m)	
GPM	= (x 0.0631 l/s)				

FIGURE G-5

TRAIN NO. 3 ALUM TP/C TREATMENT



DESIGN CRITERIA	RAPID MIX				FLOCCULATION				CLARIFIER				FILTER			CARBON		
DIAMETER, FT	–				–				4.66[2]				0.46			0.417		
SWD[3] DEPTH, FT	–				–				8.83				–			–		
LIQUID DEPTH, FT	–				–				9.33				–			–		
SURFACE AREA, SF	–				–				17[2]				0.165			0.14		
VOLUME GAL	18.3				79 – 484				769[4]				–			15.7		
STAGE VOLUME, GAL.	–				–				–				–			3.9		
TYPE	MECHANICAL MIX				MECHANICAL MIX				CONVENTIONAL				DUAL MEDIA			DOWN FLOW		
EFF BED DEPTH, FT.	–				–				–				2.5' A, .5' S			15		
CARBON, LBS	–				–				–				–			61.7[5]		
PERCENT OF DESIGN	75	100	150	MAX.	75	100	150	MAX.	75	100	150	MAX.	75	100	150	75	100	150
FLOW, GPM	9.2	12.2	18.3	22	9.2	12.2	18.3	22	8.9	11.8	17.7	21.3	5	.66	1.0	.31	42	.64
DETENTION TIME, HRS.	2.0[1]	1.5[1]	1.0[1]	0.8[1]	22[1]	16.6[1]	11[1]	8.6[1]	1.4	1.1	0.7	6	–	–	–	–	–	–
OVERFLOW, GPD/SF	–	–	–	–	–	–	–	–	750	1000	1500	1800	–	–	–	–	–	–
HYDRAULIC LOADING, GPM/SF	–	–	–	–	–	–	–	–	–	–	–	–	3	4	6	2.3	3.1	4.65
VELOCITY, FPM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–
MIXING FORCE, G, FPS/F	300	300	300	300	45	45	45	45	–	–	–	–	–	–				–
CONTACT TIME, MIN	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	50[5]	36[5]	18[6]

(1) MINUTES

(2) EFFECTIVE DIAMETER OR AREA (DEDUCTS AREA OCCUPIED BY CLARIFIER FEED WELL AND LAUNDER)

(3) SIDE WATER DEPTH

(4) SIDE WATER VOLUME MINUS FEED WELL

(5) 4 – 3.75' EFFECTIVE DEPTH COLUMNS

(6) 3 – 3.75' EFFECTIVE DEPTH COLUMNS

METRIC FORMULAS

FT	=	(x 0.3048 m)	GPD/SF	=	(x 0.0408 $m^3/m^2/d$)
SF	=	(x 0.0929 sq.m.)	GPM/SF	=	(x 40.7 l/min/spm)
GAL	=	(x 3.785 l)	FPM	=	(x 0.03048 m/min)
LBS	=	(x 6.454 kg)	FPS/F	=	(x 1.0 m/sec/m)
GPM	=	(x 0.0631 l/s)			

FIGURE G-6

carbon. A further discussion of the chemicals used and operational procedures will follow in each appropriate subsection for each individual train.

RAW SEWAGE PUMPING

The source of raw sewage for the pilot plant is in the dual influent channel immediately downstream of the plant head gates at the headworks building. The raw sewage channel is about 20 to 25 feet (6 to 7.6 meters) below the surface. One recessed vortex submersible pump has been provided for each channel. Further information and instructions for the raw sewage pumps and any other mechanical equipment are provided in an equipment maintenance manual in the pilot plant laboratory trailer.

Present practice at the Southeast plant is to use only one channel at a time. Therefore, only one submersible pump is operating at a time. A hoist is provided to lift or lower the pumps into the channel. The power source for the two pumps is one 460-volt receptacle. When changing channels or changing the pumps, the appropriate power connection must be made for each pump. All return drainage lines must be directed to the channel that is being pumped from. Extreme caution must be used in changing the pumps because of nearby hydraulic tubing used to lift and lower the Southeast plant head gates. The pump discharge piping and other hoses should be located so as not to press against the hydraulic tubing for the head gates.

During normal operation, with the submersible pumps, it should not be necessary to change the pumps in their individual channels. When the main plant changes the

particular channel they are using for the influent sewage, all that is necessary normally is to change the 6-inch (15 cm) header valves on the discharge line of the submersible pumps so that the appropriate pump is connected to the discharge line to the pilot plant headworks. Also, the proper pump must be connected to the power source. The on-off button for the raw sewage pumps is located on the electrical skid, shown on the plant layout on Figure G-7.

These submersible pumps are provided with a thermal protection device so that when the pump is not submerged in liquid the thermal protection or the heaters will open the circiut breaker on the pump, therefore, it is important to keep the pumps submerged in the raw sewage all the time. This is especially important during wet weather periods when plant operation and practice is to restrict the raw sewage flow into the plant.

This causes a flow constriction just below the plant head gate resulting in intermittent submersion of the pumps. A plank has been attached to the downstream bar rack to alleviate this condition somewhat, but during wet weather this problem might reoccur.

HEADWORKS

The headworks unit fulfills three purposes, to grind or comminute the raw sewage, to degrit it, and to meter the raw sewage flow to the appropriate process trains. The comminutor should be checked weekly for any accumulation of debris in the grinding chamber. A rag basket should

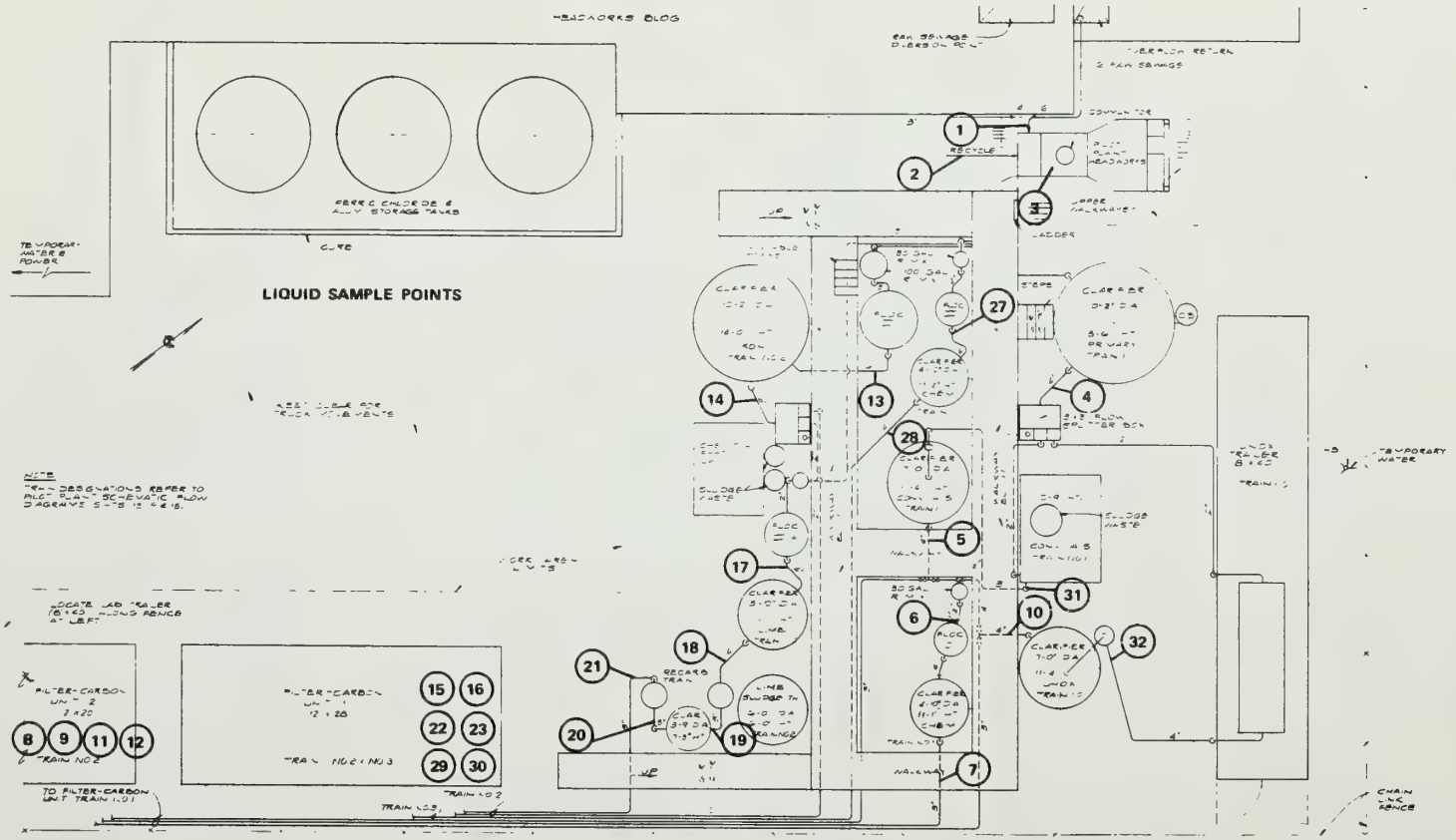


FIGURE G-7
SAN FRANCISCO PILOT PLANT STUDY
SOUTHEAST SITE PLAN

be placed on the effluent of the comminutor channel to catch fragments of rags and other debris passing through the comminutor. The rag basket should be replaced by a clean basket once a week.

An aerated grit chamber is used to degrit the comminuted sewage. The air valve to the aerated grit chamber should be operated so that there is a slight roll in the grit chamber to separate the grit from the organic material. Each day of operation the grit chamber should be cleaned manually by opening the grit chamber drain valve slightly until a portion of the raw sewage flow is passing through the grit drain. When flow is established in the grit drain, the valve can be opened completely and the grit chamber can be washed out with a hose. After the grit is cleared from the chamber the drain valve should be closed and normal operation resumed.

There are three sets of weir arrangements on the headworks. The first weir arrangement is a 4-inch (10 cm) rectangular weir located upstream from the comminutor. It is used to approximately proportion the necessary amount of raw sewage to operate the pilot plant process trains. The wastewater to be processed in the pilot plant passes through the 4-inch (10 cm) rectangular weir, through the comminutor, the rag basket, the grit chamber, and then approaches the flow splitting weirs for each process train.

There are five weirs for measuring the wastewater flow to the pilot plant trains. Weir numbers 1 and 2 are 33-1/2°

V-notch weirs. Weirs 3 and 4 are 22-1/2° V-notch weirs. The 12-inch (30 cm) rectangular fifth weir is used as a by-pass for excess raw sewage, which directs the flow back to the raw sewage influent channel of the main plant. Weir No. 1 controls the wastewater flow to Train No. 1. A gauge marked in inches is attached to weir plate for adjusting the proper height. It is important not to pull the weir entirely out of its slot since solids in the raw sewage will lodge in the slot. This reduces the length of the weir travel, and eventually requires cleaning of the slot. Weir No. 2 controls the flow to Train 2. It is constructed identically to Weir No. 1. Weir No. 3 controls the flow to the lime rapid mix tank if it is desired to treat the raw sewage with lime chemical coagulation and clarification. Weir No. 4 controls the flow to Train 3, the physical/chemical process train. Weir calibration graphs have been calculated and have been plotted to determine the amount of flow passing through the weirs for a determined head in inches on the weir. The weirs should be checked once each day or at a shorter frequency to determine that rags or other debris have not lodged in the "V" notch of the weir and restricting the flow.

A third set of weirs are located in the weir box to the left of the headworks. This set of weirs is used to proportion the Southeast sewage with another sewage for treatment in the pilot plant. This set of weirs was used when the North Point raw sewage was trucked to the Southeast site mixing 75 percent North Point with 25 percent Southeast producing a combination of raw sewage which eventually will be treated at the Southeast plant when the North Point plant is abandoned for dry weather flows.

In conjunction with this weir box operation, two Gorman Rupp trash pumps were provided to pump the North Point sewage from a holding tank to the weir box for the proper North Point-Southeast mixture of raw sewage. If the third weir box pumps are used to pump raw sewage for a mixture with the Southeast sewage they should be alternated on a day to day basis and the pumping chamber inspected daily to clear the impeller of rags, debris, et cetera.

Since the bench scale coagulation clarification tests indicate it is the best procedure to add the base to the raw sewage prior to the primary coagulant, lime is added just below the headworks weirs for Trains 2 and 3. The lime or base is fed to maintain a pH range of 6.5 to 7.5 in the chemically clarified effluent, where alum and ferric chloride are used as primary coagulants. Chemical feed graphs for all the chemicals used in the pilot plant, alum, ferric chloride, lime, polymer, have been calculated and examples are presented in Attachment G-1. Wallace and Tiernan chemical feed pumps have been provided to feed the base or lime solution to the weirs for Trains 2 and 3. The lime and other chemical mixing practices will be discussed in a later section. Experience has indicated that the shorter the discharge and suction lines for pumping the lime slurry, fewer problems will result with clogging. Therefore, the lime chemical feed pumps for Trains 2 and 3 are located on the headworks.

Since the use of lime results in considerable scaling problems inside the pump as well as the transport lines, the lime chemical feed pumps should be alternated daily to insure uninterrupted lime feed operation. The pump removed from service should be dismantled and the head cleaned with acid to prepare it for the next day's service.

A solids recycle flow splitting box has been mounted on top of the headworks building adjacent to the pilot plant headworks. This box is used to meter the Southeast treatment plant solids handling recycles into the pilot plant flow. During normal operation, the recycle flow from the solids handling processes should be equivalent to about 3 percent of the total flow. A recessed vortex submersible pump has been placed at the point of access of the plant recyle flows near the plant Parshall flumes. This pump is used to feed the solid recycle flow splitting box. Since the solids recycles contain a large amount of hair and other debris, this pump should be inspected daily and cleaned for any accumulation of such debris. A hand hoist has been provided to lift the pump out of the recycle flow for inspection purposes. The lines from the pump to the solids flow recycle splitting box are rather lengthly and they also should be flushed periodically to remove any accumulation of debris associated with the solids recycle waste.

At the headworks there is a box for mounting pH meters, chloride analyzers, and other raw sewage quality measuring devices. When in operation, these units should be inspected twice during each 8-hour shift to calibrate and clean the instrument probes. Recorders, if used, should be checked for paper supply and proper time calibration. Automatic samplers have been provided to sample the various waste streams in the pilot plant. These units are explained in their brochure in the equipment manual. Care should be taken to maintain the samplers so that rags do not block the entrance port of the sampler to

prevent collection of an erroneous sample; for instance, straining of solids from the raw sewage. In some instances, it may be advisable to collect raw sewage samples manually.

The amount of sample taken each time the automatic sampler activates is constant volume, and the desired variation in sample amount is attained by changing the frequency of the sampler activation. This is done by rotating the knurled knob on the sampler in a clockwise direction to decrease the frequency of sampling or in a counterclockwise direction to increase the frequency of sampling.

Data collection on the headworks should consist of influent pH, temperature, chlorides or conductivity, if monitored, total flow, plant solids handling recycle flow, and the head on each of the control weirs. A record of when the grit chamber was cleaned should be maintained daily. Duration of pilot plant shutdowns resulting from adverse pH's in the raw sewage should be recorded as well as the maximum or minimum pH attained during the shutdown.

TRAIN 1, PRIMARY CLARIFIER

The purpose of the primary clarifier is to settle as efficiently as possible the suspended solids in the raw sewage. The primary clarifier has a variable speed drive for the sludge collection. Adjustment of the distance between the drive and the gear reducer dictate the speed of the sludge collector mechanism. Increasing the belt tension between the drive and the gear reducer increases the speed of the sludge collector and decreasing the tension decreases the speed of the sludge collector.

Sludge removal from the primary clarifier is accomplished by hydrostatic principle. A box connected to the sludge removal point at the bottom of the clarifier is changed in height relative to the clarifier weir elevation. Lowering the box increases the rate of sludge removal and raising it decreases it. During normal operation, sludge removal for the primary clarifier is done on an intermittent basis by lowering the box for 5 to 10 minutes and then raising it back to near the weir elevation.

Air skimmers have been provided on the primary to clear the surface of floating materials and direct them towards the skimmer collection line. The skimmer collection line consists of a 1-inch (2.54 cm) Tygon tube adjusted so that it is just below the surface of the clarifier to drain off floating objects to the plant drain. This skimmer should be inspected periodically to clear it of any large objects to prevent blockage. At times it is necessary to use the pipe cleaner (snake) to clear the skimmer line. The center well in the clarifier accumulates a large amount of grease and other floating debris associated with raw sewage. This should be cleaned at least once daily with the air diaphragm pump provided for this service.

When operating on the Southeast sewage alone, an extreme fluctuation in pH can be anticipated in a range of from 2.0 to excess of 11.0 in the raw sewage. During the course of the pilot study, it has been the practice to stop the flow to the primary clarifier when the raw sewage pH exceeds the range of 5.5 to 9.5 for more than 15 minutes. This should be done by using the plug provided to the flow

at the headworks immediately downstream from weir number one. After the pH has returned to the accepted operation range, the plug can be removed and normal operation be resumed in Train 1. Certain modifications are necessary later on in process Train 1 when the raw sewage is stopped. These will be explained subsequently.

The effluent from the primary clarifier enters a flow splitting box where the flow is split between the high purity oxygen and air activated sludge processes with identical 22-1/2° weirs. A third rectangular weir is used to waste excess primary effluent. Since the high purity oxygen process uses a pump to control its reactor flow, it is important to keep ahead in its weir box at all times.

An automatic sampler has been provided in the flow splitter box to sample the primary effluent.

Data collection on the primary clarifier should include the effluent pH, the flow through the clarifier, and estimate of the amount of sludge drawn off with the hydrostatic device.

HIGH PURITY OXYGEN ACTIVATED SLUDGE

The following are typical operating parameters and visual checks regarding the UNOX system. If any of the operating parameters are not within their normal range or if the visual checks are negative, please notify Carbide personnel.

1. Are the mixer drives, recycle pump, and feed pump running?

2. Is there oxygen recirculation in each stage?

3. Is the air driven mixed liquor pump maintaining a constant level in the surge column? (If the surge column overflows into the 55-gallon (208 liter) drum, please record this occurrence in the log book.)

4. Stage 1 gas space oxygen composition range 65-85% O_2.
   Stage 2 gas space oxygen composition range 55-75% O_2.
   Stage 3 gas space oxygen composition range 50-70% O_2.
   Stage 4 gas space oxygen composition range 40-60% O_2.

5. D.O.s in all stages should be maintained between 3 mg/l and 12 mg/l.

6. The gas space pressure should be between 0.5 in H_2O and 3.5 in H_2O.

7. The clarifier blanket should be between 10 inches (25.4 cm) and 30 inches (76 cm).

8. The oxygen feed should be between 35 cu ft (0.98 cu m) and 100 cu ft (2.8 cu m) for each 4-hour period. (Please subtract the totalized flow readings for the feed and vent gas flows.)

9. The oxygen supply pressure to the trailer should be between 15 psig (1.05 kg/sq cm) and 35 psig (2.46 kg/sq cm).

10. Stage 4 mixed liquor pH should be between 6.0 and 7.5. (A stage 4 mixed liquor pH change of more than 0.5 pH units since the last reading is very significant and should be reported to Carbide personnel immediately.)

CONVENTIONAL AIR ACTIVATED SLUDGE PROCESS

The purpose of the activated sludge process is to biologically coagulate the dissolved organics and colloidal material in the primary effluent. The primary effluent mixed with the return activated sludge enters the aeration tank at 3 different locations on the aeration basin. Air flow to the basin for mixing and oxygenation is controlled by a rotometer located on the top of the aeration basin. A 7-1/2 hp (5.6 kw) air blower provides the air source for the process. Since the aeration basin level and the secondary clarifier for the activated sludge process are on the same general elevation, it is necessary to pump the mixed liquor from the aeration basin to the secondary clarifier for clarification. This is accomplished with an air diaphragm pump which should be adjusted to pump a quantity equal to the primary effluent plus the return activated sludge flow. These pumps are relatively trouble free, but the air lines must be purged of condensate daily to insure proper operation of the pump.

The secondary clarifier is provided with a sludge collection drive and skimmer identical to the primary clarifier. Sludge draw off is accomplished with a variable speed centrifugal pump which lifts the return activated sludge to the solids recycle flow splitting box on top of the aeration basin. The amount of flow to the box is regulated by varying the voltage to the pump motor. The recycle box has a 22-1/2° weir to monitor the proper

amount of flow into the aeration basin.

During the pilot plant study, the air activated sludge process was operated on a diurnal flow rate. From 0000 until 0800 the unit was operated at 0.6 of an average Q., from 0800 to 1600, 1.4 Q, and from 1600 to 2400, 1.0 Q. The average Q during the pilot plant study was 14 gpm (53 l/sec). During these diurnal loading periods the return activated sludge should be adjusted to retain the same percentage of influent flow during the entire day. For instance if 50 percent return activated sludge is the desired return rate, then the return sludge flow rate should range from 4.5 gpm (0.28 l/sec) to 9.5 gpm (0.6 l/sec) to 7 gpm (0.44 l/sec).

During the pilot plant study an unusually high level of grease accumulated on the surface of the aeration basin. This should be removed daily with the air diaphragm pump provided. The level of the mixed liquor in the aeration basin should be maintained at $\pm$ 6 in (15 cm) from the bottom of the overflow outlet. Rotometer settings on the air supply usually range from 30 to 50 scfm (0.84 to 1.4 cu m/min) to maintain a dissolved oxygen concentration in the mixed liquor at 1.0 to 1.5 mg/l. The air system appears to operate best at a F:M ratio of 0.2 to 0.3, or a Mean Cell Residence Time (MCRT) of approximately 8 days. Sample calculations to provide operation near these desired parameters are shown in the Attachment G-2. In order to maintain an optimum active mass in the system, a minimum of 25 gallons (95 liters) of return activated sludge should be wasted each day.

Since the activated sludge unit is operating on a relatively low flow, wasting of the activated sludge is accomplished on a batch basis. After the desired amount of activated sludge to be wasted is computed, the following operation is required. First, determine the rate at which the return activated sludge is being pumped into the aeration basin. Divide this flow in half by lifting the interior weir box until the proper setting is at the same elevation as the annular ring. Then waste for the necessary amount of time to produce the computed waste gallonage. After the wasting period is completed, move the interior weir box back to its normal position to stop the flow over the annular ring.

The sludge blanket should be maintained between 10 and 25 inches (25 and 64 cm) in the secondary clarifier. When the sludge blanket exceeds these ranges, the condition of sludge microorganisms should be reviewed as to settleability and activity under a microscope. Operational procedures can be modified to increase or decrease return sludge rates or wasting procedures. A record should also be maintained of the amount of activated sludge wasted.

The aforementioned grease problem also appears in the center well of the secondary clarifier and on the surface of the clarifier. This requires cleaning of the center well periodically with the air diaphragm pump and frequent maintenance of the skimmer for the secondary clarifier.

For sampling and data collection, the mixed liquor and activated sludge are composited manually, taking 100 ml

of each every 4 hours. A larger grab sample is taken once a day for the settleability tests. Automatic sampling is provided for the air activated sludge effluent. Data collected on the air activated sludge system includes the pH, and dissolved oxygen in the mixed liquor, rotometer setting, and return sludge rate, and the pH of the secondary clarifier effluent.

TRAIN 1, PHYSICAL/CHEMICAL PROCESSES

Chemicals can be used to coagulate collodial material and increase the settling rate of suspended solids in raw sewage. Chemicals normally used are aluminum and iron salts, lime, and commercial polyelectrolytes.

The Train 1 physical/chemical process as well as all of the other physical/chemical processes in the pilot plant consist of a rapid mix tank, a flocculation tank, and a clarifier. Flow to the system is adjusted with a wasting box located upstream from the rapid mix basin. The wasting box is located at approximately the same elevation as the weirs on the high purity oxygen and air activated sludge clarifiers. The box is raised or lowered to attain the correct amount of biological effluent flow through the physical/chemical portion of this train. The flow is monitored by measuring the clarifier effluent flow at the filter influent holding tank.

The rapid mix basin consists of a 30-gallon (114 liter) barrel with a drain and overflow set on a stand provided with a propeller mixer. The propeller mixer should be set at an angle so as not to produce a vortex in the

rapid mix basin. The base or lime is pumped from a 55-gallon (208 liter) barrel located adjacent to the rapid mix basin directly into the basin. Aluminum sulfate, ferric chloride, lime, or a cationic polymer can be used as primary coagulants and an anionic polymer can be added in the exit line from the rapid mix basin. The outlet on the rapid mix basin can be set at a desired elevation to produce a desired detention time for specific flow rates.

The flocculation tank is equipped with an inlet, outlet, and drain with a picket fence stirring device. In this basin the coagulated particles are stirred to increase their size to provide for efficient settling. The rotation of the stirring device should be kept at a minimum of 8 rpm to prevent deposition of solids in the bottom of the flocculation tank. The maximum rpm should be no greater than 12 rpm to prevent floc breakup during the flocculation process.

The flocculated wastewater is clarified in a 4-foot (122 cm) diameter clarifier, the effluent of which flows to the filter influent holding tank. Sludge collection is similar to the primary clarifier. The sludge draw off is accomplished with a positive displacement pump, which lifts the sludge to a flow splitting box where it may be sampled, recycled to the rapid mix basin, or wasted to the pilot plant drain. The rate of sludge draw is accomplished by varying the voltage to the pump motor to increase or decrease the rate of flow.

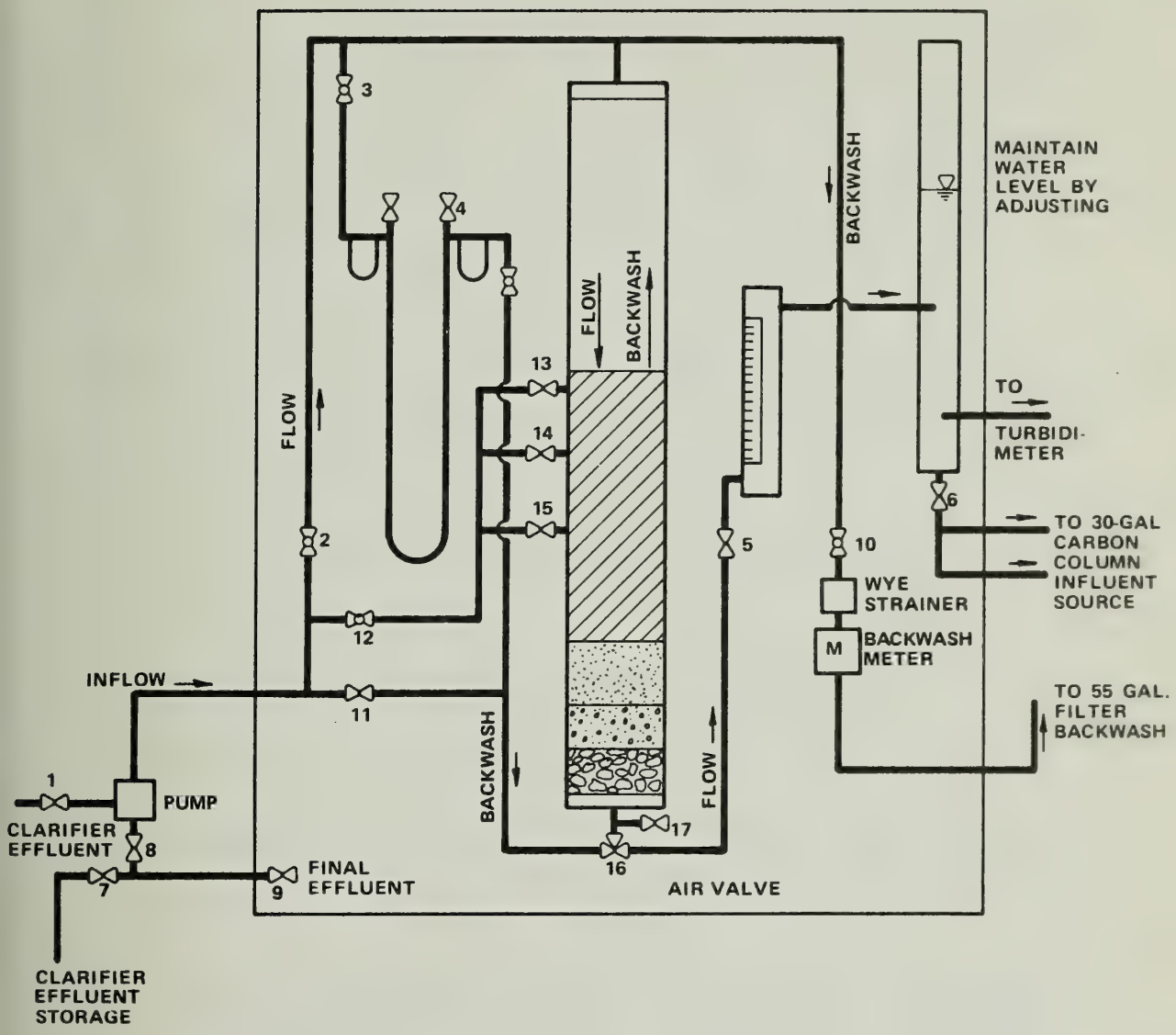
The pH of the flocculator and clarifier effluents should be maintained between 6.5 and 7.5. Chemical feed rates should be monitored by measuring the feed rate and referring to the chemical addition graphs in Appendix C. During normal operation sludge pumping should not exceed 5 gpm (0.3 l/sec). The sludge flow can be measured with a stopwatch and bucket. Automatic sampling of the sludge on this train has been provided with a solenoid sampling device. The associated timer can be used to adjust the frequency of sampling and the duration of the sample.

Maintenance in this process train includes checking the rapid mix propeller for buildup of solids or rags, which results in excessive loads on the motor. The flocculator stirring device should be checked periodically to insure freedom of movement of the center shaft. The shaft is set in a hardwood oilless seal, which tends to swell slightly causing increased friction on the shaft and subsequent motor overheating. The sludge pump requires periodic removal or replacement of the pump stator due to excessive wear in pumping the sludge.

Data normally collected on the physical/chemical portion of this train include the primary coagulant, base dose, polymer dose, and sludge rates.

FILTRATION

The purpose of the filtration process is to remove the unsettled coagulated solids produced in the chemical and



NORMAL OPERATION AT .42 gpm = 3.1 gpm/ft^2

FIGURE G-8

FILTER OPERATION

biological coagulation processes. Filtration of the chemically coagulated or the biological effluent is accomplished with a dual media filter, 3 feet in depth. The filter consists of 2.5 feet (76 cm) of anthracite coal and 0.5 feet (15 cm) of sand. The under drain consists of 3 inches (7.6 cm) each of two gradations of garnet. A schematic of the filter and the operation is shown on Figure G-8. Normal operation of the filter is at 4 gpm/ sq ft (163 l/min/sq m) or 0.66 gpm (0.04 l/sec) through the pilot plant filter column. In reference to Figure 8, normal operation of the filter or the filtering cycle consists of the following steps:

1. Valves 1, 2, 3, 4, and 16 (back position) are open.

2. Valves 7 through 15 are closed.

3. Start filter pump.

4. Valve Number 5 is used to control the flow at 0.66 gpm (0.04 l/sec).

The filtered effluent then will flow into the standpipe for the turbidimeter. The water level in the standpipe should be maintained about 5 inches (12.7 cm) above the top of the turbidimeter. This is done by regulating valve number 6. The effluent from the standpipe goes to the carbon column influent holding tank on the other side of the skid. During the normal filtration service cycle the head loss measured by the mercury manometer will increase

proportionately to the amount of solids in the clarifier effluent. After the head loss has reached a predetermined point, such as 7 inches (18 cm) of mercury head loss equivalent for a gravity filter or approximately 14 inches (36 cm) of mercury head loss for a pressure filter, the filter column should be backwashed.

The backwash operation consists of the following steps:

1. Valves 3 and 4 should be closed simultaneously so as not to drive the mercury out of the manometer. Care should be taken in this step, to prevent having the unnecessary task of removing the mercury from the mercury trap and putting it back into the manometer.

2. Close valves 5, 2, and 1 in that order.

3. If backwash source is to be final effluent, open valves 8, 9, and 10. If the filter influent is to be used for the backwash source, then open valves 7, 8, and 10.

   However, since the pilot filter column has a monel screen as an underdrain, it is not recommended to

use clarifier effluent for a backwash source, since solids may clog the small holes in the monel screen. In full-scale plant operation, it is the normal practice to use clarifier effluent to backwash filters, but because of the possible plugging problem with the pilot filters, it is better to use the final effluent.

4. Open valves 12 and 13. This provides the surface wash for the top of the filter media. Continue to surface wash the media for about 1 minute.

5. Open valve 11 slowly to allow the backwash water to lift the filter media, sand, and anthracite, not the garnet. Once expansion occurs, valve 11 can be opened completely. The sand and anthracite may rise as a plug in the filter column during the initial portion of the backwash. If this occurs, allow the media to pass up past the surface wash, and this will usually breakup the media. Caution should be taken to insure that the media does not rise far enough so that the media is washed entirely out of the column. If the surface wash fails to breakup the plug, then a rubber hammer should be used to tap on the column "lightly" to breakup the plug. If these methods

do not reduce the problem of the media plug, then turn off valves 13, 12 and 11 and unplug the filter pump. Change valve 16 so that the handle points out from the bottom of the filter column. Attach the air line to the valve 16 and slowly open the valve 17 or the air valve. This will air wash the media and will break up the media plug. Caution should be used not to turn the air too high as the media may be washed out of the filter column. After the plug is broken with the air, turn off valve 17, the air valve, change the handle on valve 16 so that it points toward the filter, remove the air line, and repeat steps 4 and 5. After opening valve 11, completely observe the washwater after it has passed through the filter media until it has visually become clear and removed most of the solids lodged in the filter. After you are satisfied the backwash water has cleared, the backwash must be terminated. This is done in the following steps:

1. Close valve 10, 13, 12 and 11.

2. Open valve 2 and throttle the flow with valve 5 to 0.66 gpm (0.04 l/sec).

3. Filter with final effluent water for about 5 minutes and adjust the standpipe height with valve 6.

4. Open valves 3 and 4 simultaneously to measure the initial head loss across the clean bed. If the head loss is not less than 2 inches (5 cm) the bed needs further backwashing.

5. Close valves 8 and 9, and open valve 1. The filter is now restored to its service cycle.

6. Valves 14 and 15 are not normally used during the backwash cycle. Experience has shown that they are not that beneficial in breaking up the media.

There is a wye strainer located between valve 10 and the watermeter on the back wash effluent line. After completing the backwash cycle, the wye strainer screen should be removed and cleaned with compressed air. After cleaning, reinsert the strainer screen back into its proper position.

Data collection for the filter is shown on Data Sheet K. The date and time the filter run was started, the head loss, turbidity reading should not be taken until 30 minutes

have elapsed since the filter was put back into its service cycle, because it takes about 15 minutes for the turbidimeter to stabilize after the backwash cycle.

Chemicals possibly used to treat the filter influent are alum for coagulation, polymer to maintain stability in the bed, and hypochlorite to clear the media of any organic growths.

This concludes the discussion of the filters and the filtration operation. These are five identical filter modules at the pilot plant located on the skids shown in Figure G-7.

ACTIVATED CARBON ADSORPTION

The purpose of the activated carbon adsorption process is to remove dissolved organics such as pesticides, color, detergents, and hydrocarbons from the filter effluent. The filter effluent storage, or carbon column influent, is located on the opposite side of the skid of the filters and carbon columns. Normal flow-through rates in the carbon column are about 3 to 4 gpm/sq ft (163 l/min/sq m) with 20 to 30 minutes detention time. In reference to

FILTER NO. 3 11 15 22 29 BACKWASH NO. 47 52 56 66 70

DATE TIME

END _____ _____ H_L _____ TURB. _____ BY _____ STOP _____

START _____ _____ H_L _____ TURB. _____ BY _____ START _____

LENGTH _____ TOTAL _____

SOURCE _____

TIME	BY	FLOW gpm	H_L in. Hg	TURB.	ALUM			NaOCl			TOTAL FILTERED Gals.	CLARIFIER FLOWS gpm				
					Aim	ml/m	Dose	Aim	ml/m	Dose		7	10	28	21	14

COMMENTS: _____

_____

_____

DATA SHEET K

Figure G-9 normal operation of the carbon columns consist of the following steps:

1. Two way valves 20, 21, 22, 23 are open (handle in the up position).

2. Valve 24 is open (handle in forward position).

3. Valves 25, 26, and 27 are in the open position (handle pointed to the right).

4. Valves 29, 30, 31, and 32 are in the closed position (handle toward skid wall).

5. Valve 33 is closed.

6. The small centrifugal pump is started and flow is initiated through the four carbon columns, the Dole flow controller, the flow rotometer, and the water meter to the final effluent storage.

7. Valve 19 is used as a bleed off valve to control the amount of water entering the carbon columns. Pressure meters in psi are located on the tops of the

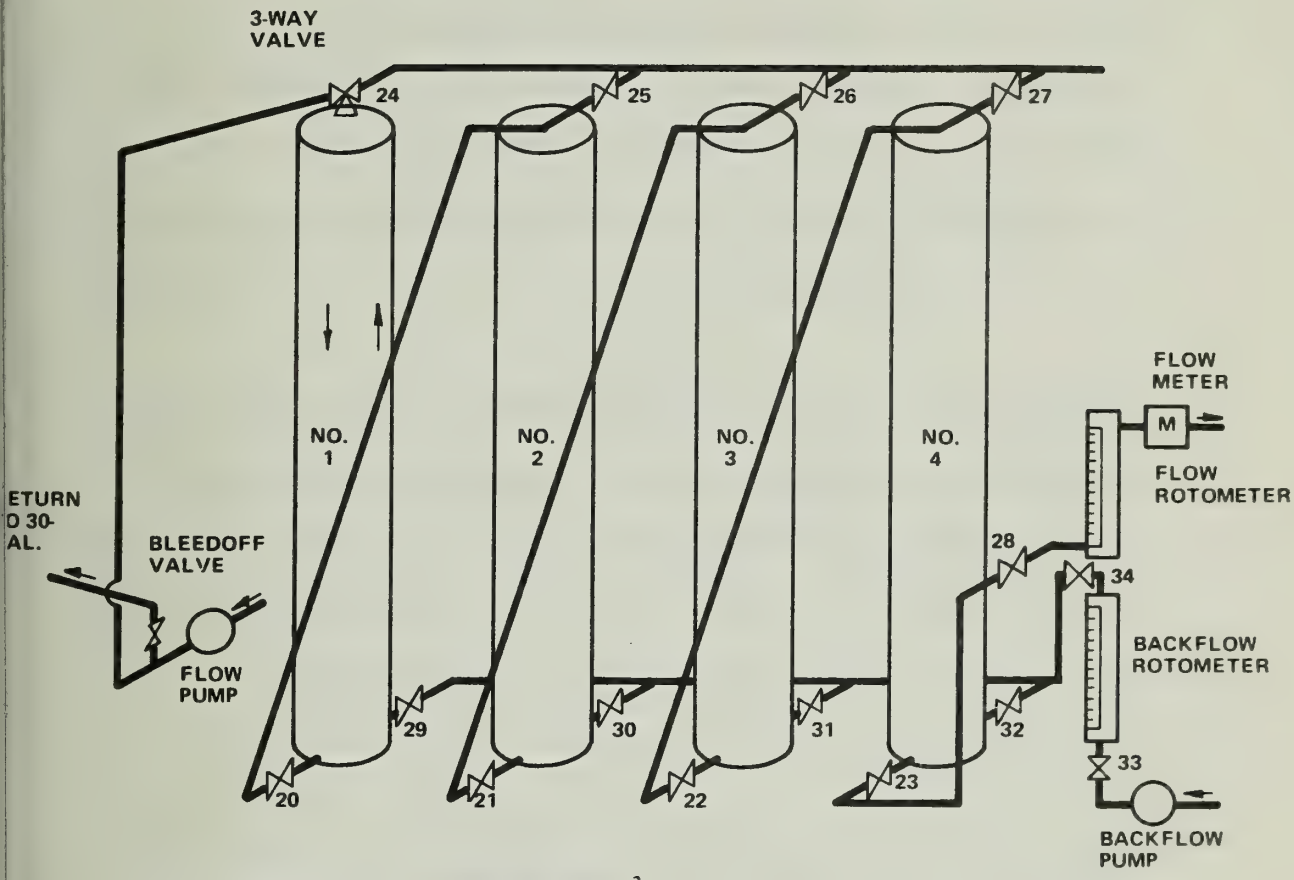


FIGURE G-9

CARBON COLUMN OPERATION

four carbon columns. The bleed off valve should be adjusted to control the flow to the carbon columns so that the pressure gauge reading in column 4 is between 10 and 20 psi (0.7 and 1.41 kg/sq cm). At the initial portion of the run, the pressure differential between the number 4 and number 1 columns should be relatively small.

8. The effluent flow rotometer should be adjusted with valve 28 to the desired flow-through rate for the carbon columns, for instance, 0.42 gpm (0.03 l/sec) is equivalent to about 3 gpm/sq ft (122 l/min/sq m) This flow rate was used during the pilot plant study.

9. Therefore, there are two flow controllers on the carbon column system, valve number 19 and 28 to control the total flow and also the pressure on the carbon column system. These two valves should be used to regulate the carbon columns at the proper pressure and flow-through rate.

During the carbon column service cycle, there will be a buildup of head loss across the columns 1 to 4, depending

upon the quality of the filter effluent applied to the carbon column. When the pressure differential between columns 1 and 4 reaches 5 psi (0.35 kg/sq cm) the carbon columns must be backflowed to clear them of accumulated solids. The service cycle is terminated by turning off the feed pump and closing valves 20 to 24 (handle in side position).

Backflow is usually accomplished at 12 to 15 gpm/sq ft (488 to 611 l/min/sq m). Either one or two columns may be backflowed at a time, but usually two columns are backflowed together.

The procedure for backflowing columns 1 and 2 consists of the following steps:

1. Open valves 29 and 30 (back position), valve 24 (side position), valve 25 (back position).

2. Start backflow pump using final effluent as carbon backwash source.

3. Adjust flow in backflow rotometer with valve 33. Flow should be about 3-1/2 gpm (0.22 l/sec) for 2

columns. Observe the carbon columns as the backflow water passes through. If the carbon column rises as a plug, use the rubber hammer to tap the column to break up the plug. Observe if there are any mud balls formed at the top of the carbon column which have settled to the bottom of the carbon column. Also use extreme caution not to backflow the carbon out of the carbon column into the backflow storage tank. If this occurs, the backflow storage tanks have been provided with a bucket to catch the flow and wettle out the carbon granules. If a large amount of the carbon granules have been washed out of the column, the bucket should be emptied back into the carbon column. This is done by removing the wing nuts on the top cover of the carbon column and pouring the carbon back into the column.

4. If the carbon plug will not break up or several mud balls are present, the column should be air washed by using the following procedure.

5. Turn off backflow pump.

6. Attach air valve 17 to valve 34.

7. Bubble air through column until plug breaks or mud balls are broken up. Be cautious not to blow carbon out of column.

8. Turn off valves 17 and 34.

9. Backflow the columns for about 5 to 10 minutes, while observing the clarity of the water above the column. After you are satisfied the column has been cleaned

completely, the backflow operation can be terminated with the following steps:

1. Shut off the backflow pump and close valve 33.

2. Close valves 29 and 30 (side position), close valve 25 (side position).

3. Leave valve 24 in the same side position.

4. Backflow columns 3 and 4, open valves 26, 27, 31 and 32 (back position).

5. Start the backflow pump and using valve 33 adjust the flow to about 3-1/2 gpm (0.22 l/sec) through the 2 columns.

6. Observe the carbon column for plugging media or washing out the column. Air washing and backflow periods remain the same as before. The backflow cycle for columns 3 and 4 can be terminated with the following steps.

    1. Turn off the backflow pump.

    2. Close valve 33.

    3. Close valves 31, 32, 26, and 27 (side position). Restore the carbon columns to the normal service cycle using the previously discussed procedure.

Carbon column samples are taken manually.

Data collection across the carbon column includes monitoring the flow totalizer or watermeter, the flow rate on the rotometer, and the pressure across the 4 carbon columns. During the backflow procedure, the length of time each column is backflowed and the rate should be recorded so that the total quantity of water used to backflow the carbon column can be computed. The pressure in each column after backflowing should also be recorded.

There is a plastic wye strainer on the effluent of the number 4 column which is used to strain any carbon granules that may possibly escape from carbon column number 4 and prevent them from plugging the flow controller, rotometer and water meter. This wye strainer should be cleaned periodically, at least once a week, to ensure efficient operation of the carbon column.

There are five identical carbon column modules on the filter skids, located next to the upstream filter, for each process effluent.

Tanks have been provided on the up side of the skid from the filters and the carbon columns to collect backwash water from the filters and the carbon columns. The backwash waters can be metered into a holding tank where they may be pumped back to the rapid mix basin for the associated train to simulate recycle flows in a full-scale plant. However, since the filters and carbon columns are operating at less than 1 gpm (0.06 l/sec) rate, only about 5 percent of the necessary washwater is generated with the actual backwashing of the pilot filters and carbon columns. Therefore, if an actual

recycle situation is desired to simulate full plant conditions, approximately 95 percent of the backwash must be simulated. This can be done by taking the clarifier effluent solids and the sludge solids from the clarifier in the associated upstream process and mixing them together in the proper proportion to simulate backwash recycles. The final effluent storage tank is located adjacent to the backwash tanks.

TRAIN 2, TWO-STAGE PHYSICAL/CHEMICAL TREATMENT OR RAW SEWAGE

The purpose of the two-stage chemical coagulation processes is not only to remove additional suspended and colloidal matter, but also to achieve additional metals removal and preparation for filtration. The process train consists of a ferric chloride coagulation and clarification with lime for pH adjustment and polymer as a coagulant aid.

As previously described, the base for the Train 2 ferric chloride coagulation process is added at the head works weir in the form of calcium hydroxide. The rapid mix basin for the ferric process is a 100-gallon (378 liter) tank with a similar mixer as for Train 1. Ferric is added in the rapid mix basin and the polymer is added at the outlet of the basin. The coagulated effluent is flocculated to increase particle size and clarified in a tank identical to the primary clarifier, complete with a skimmer.

During the pilot plant study, the ferric chloride dosage was maintained at approximately 175 mg/l. The lime dosage

was maintained to achieve a final pH of 6.5 to 7.5 in the clarifier effluent. The anionic polymer dosage rate was maintained at 0.5 mg/l.

Sludge removal is accomplished with a hydrostatic box identical to the primary clarifier. However, this clarifier is operated with a continuous sludge removal with the box being situated such that about 6 to 8 gpm (0.38 to 0.5 l/sec) of sludge is drawn off the clarifier continuously. Approximately once every hour the box should be lowered for about 3 to 5 minutes to clear any accumulated solids in the line and in the bottom of the tank and then adjusted back to the original position. This procedure has been simplified using a chain binder, by just opening and closing the chain binder to adjust the level of the sludge flow box.

The ferric coagulation and clarification effluent flows to a box identical to the Train 1 splitter box. The flow is divided with two 22-1/2° V-notch weirs and a rectangular weir for excess flow. The water level in the splitter box is adjusted by moving the rectangular weir up and down.

Chlorine in the form of sodium hypochlorite or calcium hypochlorite is added to the weir box for direct filtration and activated carbon processes to retard organic growth in the pipeline. The dosage is maintained at approximately 2 to 5 mg/l.

HIGH LIME COAGULATION AND CLARIFICATION

The portion of the flow being directed to high lime treatment enters a rapid mix basin identical to Train 1 basin.

Lime is added with chemical feed pumps at dosages ranging from 250 to 600 mg/l of calcium hydroxide. The lime pump has its individual storage tank for the 10 percent lime solution. Since this pump is pumping large quantities of the lime slurry it is very important that it be changed daily to clear the pumping chamber of lime scale. The 0.5 mg/l dosage of polymer is added at the exit of the rapid mix basin.

It is important that the pH in this process train be maintained between 11.2 and 11.5. Operation of this clarifier below 11 will result in a milky, turbid effluent. A solid state pH probe with a glass electrode has been installed in the flocculation tank to control the lime coagulation-clarification process. The readout is located so that the pH in the flocculation tank can be monitored at a glance.

Since the environment in which the pH probe is highly scaling, it is important that this pH probe be calibrated at least once every 3 days by removing the probe from the flocculator and immersing it in a pH buffer of 9 or higher to standardize the instrument. The probe itself should be cleared of scale once every 2 or 3 weeks.

The lime flocculation effluent is settled in a 5-foot (152 cm) diameter clarifier with the high pH effluent flowing to the first stage recarbonation feed pump holding tank.

The sludge draw off from the lime sludge clarifier is accomplished with a Moyno pump. The lime sludge pump lifts the sludge to the solids recycle tank where it can be recycled back into the rapid mix basin or flow directly to the lime

mud thickener located adjacent to the lime clarifier. A solids recycle metering box is located to gravity return lime sludge to the rapid mix basin to provide a nucleus for the lime floc to form more efficiently. This box is identical to the headworks recycle and the activated sludge recycle boxes.

A center weir box can be lifted to the desired height to return any desired amount of lime sludge from the bottom of the lime clarifier to the rapid mix basin. During the course of the pilot plant study, excellent clarification and formation of the lime solids was obtained so that lime sludge recycling was not normally practiced. The lime sludge flow should be maintained at less than 1 gpm (0.063 l/sec). There should be no problem with a buildup of lime sludge in the clarifier at these rates. The lime sludge also may be wasted directly to the pilot plant drain. The stator on the lime sludge pump should be cleared of lime scale periodically.

Data collection around the ferric clarifier should include chemical feed rates for ferric chloride base, polymer, and the amount of sludge removed continually.

Train 2A, the lime system, should include the amount of lime and polymer fed in terms of dosage and monitoring of the pH at the outlet of the flocculation basin. The lime sludge clarifier effluent pH should be recorded as well as any recycle flows, be they lime sludge or simulated solids recycles flows from backwash and recalcining operation.

Two-Stage Recarbonation

The purpose of recarbonation process is to reduce the high pH effluent to neutral while accomplishing additional dissolved solids removal. Calcium ions can be precipitated by reducing the pH 11 effluent to the range of 9.5 to 10, resulting in the formation of the maximum amount of calcium carbonate precipitate. Carbon dioxide is normally used to reduce the pH to these levels.

At the pilot plant, flow is metered through rotometers into a 55-gallon (208 l) barrel that serves as a first stage recarbonation reactor. CO_2 from 50-pound (23 kg) cylinders is bubbled into the reactor. The effluent pH from the first stage reactor should be monitored by taking a sample at the outlet of the tank and waiting 5 to 10 minutes for complete CO_2 reaction before pH analysis. The proper pH range is from 9.5 to 10.

A rotometer is used to control the amount of CO_2 added to the first stage. If the proper amount of CO_2 has been added, the clear effluent from the lime clarifier turns milky. The first stage effluent flows to the recarbonation clarifier for removal of the precipitated calcium carbonate solids. The clarifier effluent passes to the second stage recarbonation basin, where CO_2 is bubbled into the tank. Control is achieved by means of a rotometer to reduce the pH 9.5 water to pH range of 7 to 7.5. Again, after a sample is taken, a reaction period of 5 to 10 minutes should elapse before measuring the final pH.

Since the recarbonation process develops a very highly scaling water it is important that lime scale be removed

from the diffusers holes on the CO_2 system and from the rotometer for measuring the flow to the first stage recarbonation basin. Two rotometers have been provided to provide for removal and cleaning of one rotometer while the other is in operation.

The carbon dioxide header system allows for four 50-pound (23 kg) tanks to be online at one time. Also one tank can be used at a time if desired. The pressure of the fresh cylinders will be around 800 to 900 psi (56 to 63 kg/sq cm). As the tanks or tank empties the pressure will fall, eventually reaching 0 psi (0 kg/sq cm). It is important that the tanks do not empty completely, because when the tanks are charged, atmospheric air will enter the tank. This results in unnecessary purging of the wet atmospheric air from the tank by the carbon dioxide supplier and then refilling with the dry CO_2 gas. The normal procedure is to let the pressure decrease on the manifold header for the tanks to about 50 psi (3.5 kg/sq cm) and then remove the tank from the system so that the tank is still pressurized. A second gauge on the carbon dioxide regulator provides a reading on the pressure in the discharge lines to the recarbonation basins. Since the pilot plant reaction basin tanks are only about 40 inches (102 cm) in height, it is very important that the pressure in the discharge system be maintained in the range of 5 to 10 psi (0.35 to 0.7 kg/sq cm), preferably at 5. Higher pressures result in waste of carbon dioxide since the vertical rise of the bubble is very short compared to optimum full-scale plant design, which should be around 8 to 9 feet (2.44 to 2.74 m).

The sludge flow on the recarbonation clarifier should be no more than 1/2 gpm (0.03 l/sec) for the pilot plant. This is sufficient to clear the calcium carbonate precipitate from the clarifier. An automatic sludge sampler on a timer with duration and frequency of sampling have been provided on the recarbonation sludge lime. The recarbonation sludge is pumped to the sampling device and then flows to a compositing tank where it can either be recycled to the rapid mix basin of Train 2A, be wasted to the pilot plant drain, or be stored in the lime sludge thickener. The effluent from the second stage recarbonation system flows to the filtration and activated carbon processes previously described in Train No. 1.

Data collection across the recarbonation system includes the amount of flow passing through the system, rotometer settings for CO_2 addition, in scfm, pH monitoring of both the first and second stage effluents, and sludge flow on recarbonation clarifier.

TRAIN 3, PHYSICAL/CHEMICAL PROCESS

This physical/chemical train is identical to Train 1 physical/chemical train in configuration and size. Lime is added at the headworks as previously described for pH control on the clarifier effluent. Any primary coagulant can be used such as alum, ferric, lime, or a cationic polymer. An anionic polymer can be added to the effluent line from the the rapid mix basin to the flocculation basin.

The flocculated effluent flows to the clarifier where the solids are settled out with effluent flowing directly to

filtration and activated carbon adsorption previously described in Train 1.

Chlorine is added in a dosage of 2 to 5 mg/l to the clarifier effluent to retard organic growth and slime growths in the pipeline from the clarifier to the filtration influent holding tank.

Sludge is removed from the clarifier using the hydrostatic principle with a sludge removal box described previously for Train 2, complete with chain binder to lower and raise the level of the box. A skimmer identical to the those previously described is also located on the surface of the Train 3 clarifier.

Data collection across this Train 3 physical/chemical clarification and coagulation system includes monitoring of the dosage of the primary coagulant as well as base and polymer dosages. The flocculation and clarification effluent pH's should be maintained between 6.5 and 7.5. The sludge flow rate should be monitored and kept to a sufficiently low level so as not to reduce the desired clarifier overflow rate. The sludge removal system used with the hydrostatic head device requires that a flow of 3 gpm (0.19 l/sec) is necessary to prevent plugging.

CHEMICAL MIXING AND ADDITION

Almost all the chemical mixing is accomplished in the chemical feed area shown in Figure G-7. Calcium hydroxide or lime is mixed in a 200-gallon (757 l) barrel with a propeller mixer. The barrel is calibrated so that at

any particular level in the barrel, the appropriate pounds of calcium hydroxide and water can be added to bring the tank to the desired full level and still maintain the 10 percent lime solution which is being added to the various process trains. Figure 1, Attachment 1 is provided to compute the correct amount of lime and water to replenish the lime supply.

Aluminum sulfate is mixed on the same platform in a 55-gallon (208 l) drum which is again calibrated to facilitate addition of the correct amount of dry aluminium sulfate and water to maintain a 20 percent solution in the tank. Figure 2 is provided in Attachment 1 for correct mixing quantities.

The polymer is mixed in two 200-gallon (757 l) tanks calibrated similar to the lime tank, and Figure 3 Attachment 1 is provided for adding the correct amount of polymer and water to produce a 0.1 percent solution. An aspirator is provided to wet the dry polymer before it enters the mixing tank.

After the 10 percent lime solution is mixed, it is pumped with a centrifugal pump and garden hoses to three different tanks for addition into the various physical/chemical systems. The general equation for chemical addition for all chemicals is shown in Attachment 1. In addition,for aluminum sulphate, ferric chloride, lime, and polymer, dosage graphs for the various pilot plant flow rates (75 percent, 100 percent, 150 percent, Maximum percent) have been drafted and are placed in a chemical addition binder at the laboratory trailer.

If the propeller mixer malfunctions, the contents of the lime tank can still be mixed. This is done by pumping the contents from the bottom of the tank back to the top of the tank via a controlled splitter box.

This method can also be used to add lime to Train 2A, however, the pump stator life is very short when pumping the abrasive lime solution. Replacement stators are available for the pump at the pilot plant. Since the stators available for the pump are not of industrial grade wear resistance, usable stator life is usually only 3 to 5 days.

Care should be taken to flush the lime transfer pump and the garden hoses after transferring lime to the chemical addition tanks, as scaling will eventually plug the lines completely. A manifold system has been set up to facilitate this maintenance program. After pumping lime slurry, tap water is introduced into the suction of the centrifugal pump and water is pumped to the pilot plant drain. The primary and secondary lime storage tanks should be inspected periodically to determine if any inerts have built up in the bottom of the respective tanks. If there has been any buildup, these should be removed as they will plug the suction lines of the chemical addition pumps.

When mixing the lime or any of the other chemicals, it is important to wear the full face mask and respirator to prevent irritation of the eyes and mucous membranes.

The chemical addition pumps for adding the alum to the wastewater flow are located on the chemical mixing platform.

The 20 percent alum solution is pumped directly to the wastewater flow with no dilution required. During the pilot plant operation there was very little problem with plugging or clogging of the discharge lines from the chemical pumps.

Also the polymer addition pumps are located on the chemical mixing platform which pump directly into the wastewater flow. A manifold system to dilute the 0.10 percent solution with tap water has been provided to obtain more efficient distribution of the polymer.

Sodium nitrate is mixed at the platform in a 24 percent solution with a 5-gallon (19 liter) barrel, with 1 pound of sodium nitrate and 5 gallons (19 liters) of water. This is carried to the filter and carbon column skids for addition to the carbon column influent with chemical metering pumps. Normal dosage used is around 5 mg/l to control H_2S odors in the carbon column effluent. The carbon effluents, especially the physical/chemical effluent, should be monitored daily for any detection of hydrogen sulfide odors resulting from organic growth in the carbon columns as a result of anaerobic conditions. The sodium nitrate is reduced by organic growths in the carbon column producing elemental N and O_2, instead of H_2S.

Sodium hypochlorite for organic growth control in pipelines and in filters is mixed by adding 1 gallon of the 14 percent available chlorine, sodium hypochlorite to 24 gallons (91 liters) of tap water producing an approximate 0.5 percent solution. This solution is pumped either into a clarifier effluent weir or directly into a filter influent line.

Copper sulfate has been used at the pilot plant to control algal growths in the filter influent holding tanks. Approximately 1 pound of the large granular copper sulfate crystals placed in the tanks retards algal growth quite well.

EQUIPMENT MAINTENANCE AND DESCRIPTION MANUAL

A looseleaf notebook containing manufacturers' literature on the equipment used at the pilot plant is in the laboratory office. A listing of the lubrications and general maintenance for the pilot plant equipment is on the following pages.

The equipment requires, in addition to the routine program of maintenance, an intuitive "feel" in order to keep it running smoothly. The following represents only the routine programs.

1. Sutorbilt air blower: Clean air filter weekly. Wash in kerosene, dry and then soak in 30-50 wt. oil. Drain and replace lube bearings every 2-1/2 weeks. Change oil at 2 months. Use 20 wt. MS. No multi-viscosity.

2. Wemco sewage pumps: No normal maintenance.

3. Price pumps: Most are lifetime lubed. On those with oil caps at motor end, add several drops of 30 wt. monthly.

4. Precision Control metering pumps: No normal maintenance.

5. Wallace & Tiernan Pennwalt pumps: Lube yearly. Diaphragm valves, et cetera are most effectively cleaned in HCl. These need cleaning only when output is reduced, or plugging occurs.

6. Rotometers: Clean in HCl when visibility is reduced.

7. Cleveland Mixer: Grease every 3 months.

8. Yale Hoist: Check oil level monthly.

9. Chicago Pump Co. comminutor: Monthly grease at ball check (Zirk) grease fittings. Add SAE 30 wt. MS to gearhead. Bring to plug level.

10. Carbon Columns: No normal maintenance. Do not run pumps dry - impellers will wear out quickly.

11. Walden air pumps: Check oil bowl weekly. Add only 10 wt. nondetergent oil to fill plug level. Pump will occasionally plug due to greasy influent. This may be cleaned by filling inlet with water and throttling some and then sharply releasing the throttling valve several times.

12. Reliance equipment: No normal maintenance. Note that U.S. Drive motors, while interchangeable, may be wired nonuniformly. Note also that seals at motor to gearhead have been reparied. Observe flocculators paddles closely when operated above 15 rpm. Train 1 and 3.

13. Reeves drive: Oil motor slide monthly (30 wt.) Grease "Vari-disc" pulley biweekly. Monthly check gearhead, add SAE 140 wt. EP gearlube if needed.

14. Hydragard samplers: No normal maintenance. Malfunctions can usually be cleared by disassembly and washing all parts in soap and lukewarm water. Rinse and blow dry with compressed air.

15. Hach turbidimeter: No normal maintenance. Bulb is most common failure (GE 1630).

16. Quincy Compressor: Change oil every 90 days (3/4 qt. SEA 20 wt.). Drain condensate daily.

17. Gorman Rupp trash pumps: Check shaft grease (at plug) and automatic grease cup biweekly. Use #2 gun grease.

18. Twistair Compressor (Joy Mfg. Co.): Daily check oil/air separator indicator. Drain some condensate (open valve slightly for 1 second). This unit has an automatic condensate trap which will lose its prime if valve is opened longer. Check oil at oil level sight glass (add only Chevron 45X. Pressure must be released to do so.) Bi-weekly check air temperature switch. Clean oil cooler fins. Yearly change oil and filter Flygt pump. No normal maintenance.

ATTACHMENT 1

CHEMICAL SOLUTION PREPARATION

CHEMICAL MIXING

CHEMICAL SOLUTIONS

Lime	10%	$Ca(OH)_2$ 0.87 lbs/gal.
Alum	20%	Dry aluminum sulfate 1.85 lbs/gal.
Ferric Chloride	42-44%	4.6 lbs $FeCl_3$/gallon (Pickle Liquor Assay)
Polymer	0.1%	.0084 lbs/gal.
Chlorine	.7%	1.4 lbs available Cl_2/gal. (1 gal. 14% Cl_2 per 24 gal. H_2O)
Sodium Nitrate	5%	0.064 lbs NO_3-N/gal. or 0.4 lbs $NaNO_3$/gal. (2 lbs $NaNO_3$ per 5 gal. H_2O)

GENERAL EQUATION:

$$\frac{\text{Process train flow rate, gpm}}{700} \times 8.34 \times \text{desired dosage} = \text{lbs req./day}$$

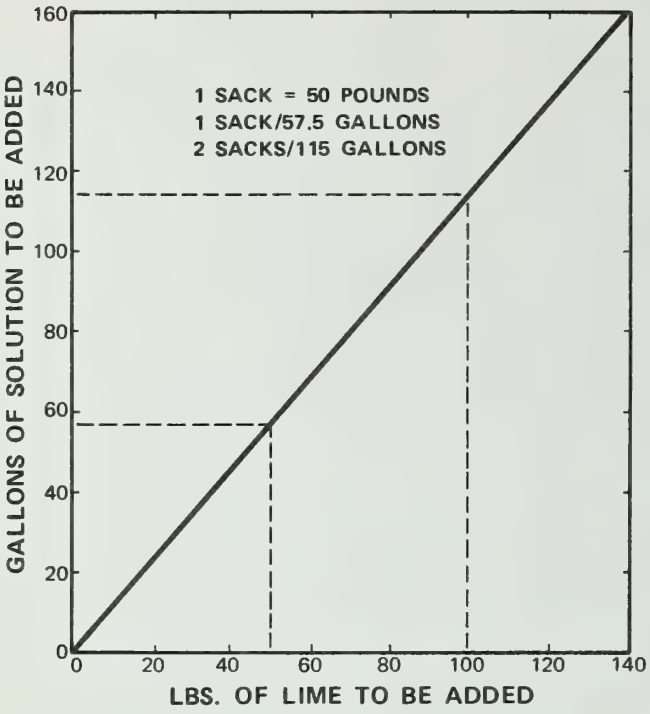
$$\frac{\text{lbs chemical req./day}}{\text{lbs chemical/gal.}} \times 2.62 = \text{ml/min. chemical addition}$$

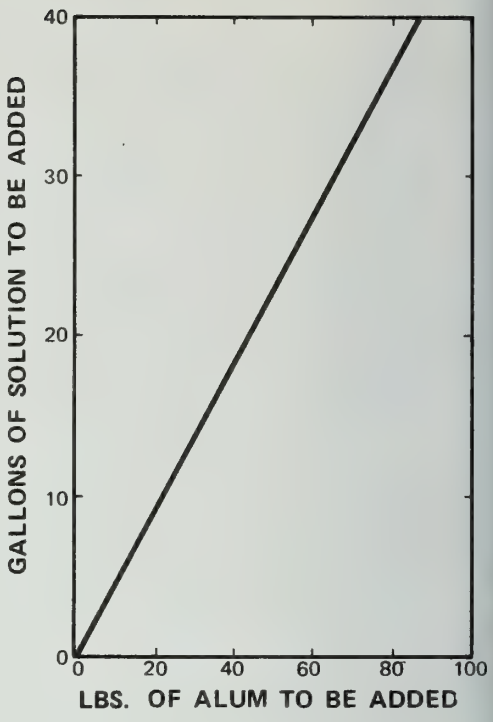
EXAMPLE:

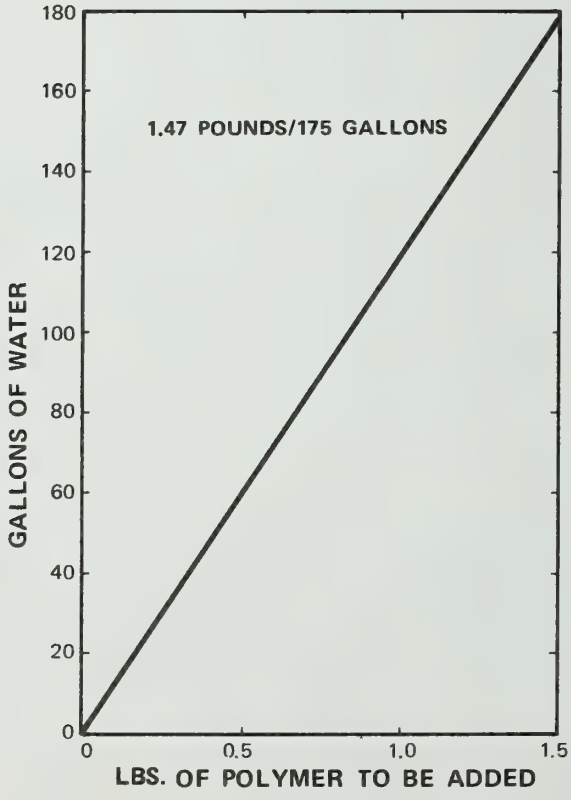
Feed alum at 250 mg/l dosage in 16 gpm flow

$$\frac{16}{700} \times 8.34 \times 250 = 47.7 \text{ lbs req./day}$$

$$\frac{47.5 \text{ lbs/day}}{1.85 \text{ lbs/gal.}} \times 2.62 = 67 \text{ ml/min}$$







ATTACHMENT 1

ATTACHMENT 2

A/S LOADING

ACTIVATED SLUDGE (AIR)
OPERATING CRITERIA

OPERATIONAL GOALS:

1. Food to Microorganism Ratio – 0.2 ~ 0.3
2. Mean Cell Residence Time – ≈ 7 to 8 days

$\frac{F:M}{Food}$ = Pounds of BOD utilized per day

Microorganisms = Pounds of Mixed Liquor Volatile SS

a. S.E. PLANT (AVERAGE)

Primary effluent BOD ≈ 175 mg/l
Secondary clarifier BOD ≈ 25 mg/l
150 mg/l

(150 mg/l) (8.34) $\frac{14 \text{ gpm}}{700 \text{ gpm/MG}}$ = 25 pounds utilized per day

b. PILOT PLANT MIXED LIQUOR ANALYSIS

MLTSS – 4,440 mg/l
MLVSS – 3,960 mg/l
Return AS TSS – 12,980 mg/l
Return AS VSS – 9,880 mg/l

c. AERATION BASIN VOLUME 4,338 gallons

(3,960 mg/l) (8.34) (0.004338) = 143 pounds of MLVSS

$F:M = \frac{25 \text{ lb BOD utilized}}{143 \text{ lb MLVSS}} = 0.17$

Would like to be at 0.2 F:M, which requires wasting a portin of the mixed liquor.

Assuming primary effluent BOD remains relatively constant the denominator in the ratio must be decreased.

$\frac{25 \text{ lb BOD}}{X} = .2$ X = 125 pounds MLVSS

(X) (8.34) (0.004338) = 125 pounds per day MLVSS

X = 3,455 mg/l

143 lb MLVSS
125
18 lb MLVSS to be wasted

ACTIVATED SLUDGE (AIR) (Cont'd)
OPERATING CRITERIA

OPERATIONAL GOALS: (Cont'd)

d. RETURN AS VSS = 9,880 mg/l

Pounds of VSS in 1 gallon

$$9{,}880 \times 8.34 \times \frac{1}{1\ MG} = 0.082\ lb\ VSS/gal.$$

e. $\frac{18\ lb}{0.082\ lb/gal.} = 219$ gal. to be wasted

f. At 7 gpm return rate (50%), waste at 3.5 gpm

$$\frac{219\ gal.}{3.5\ gpm} = 63\ min.\ of\ wasting$$

MEAN CELL RESIDENCE TIME = θc days

$$\theta c = \frac{lbs\ MLVSS}{lbs\ VSS\ wasted/day}$$

deliberate and over weir

V = 4,338 gal.

X = 3,960 mg/l MLVSS

VSS wasted

18 lbs from above

VSS over weir = 16 mg/l

$$\left(\frac{14\ gpm}{700}\right)(8.34)(16) = 2\ lb$$

$$\theta c = \frac{(.004338)(8.34)(3{,}960)}{20\ lb}$$

$$\theta c = \frac{143\ lbs}{20}$$

θc = 7.1 days

ATTACHMENT 3

LIST OF CHEMICAL SUPPLIERS

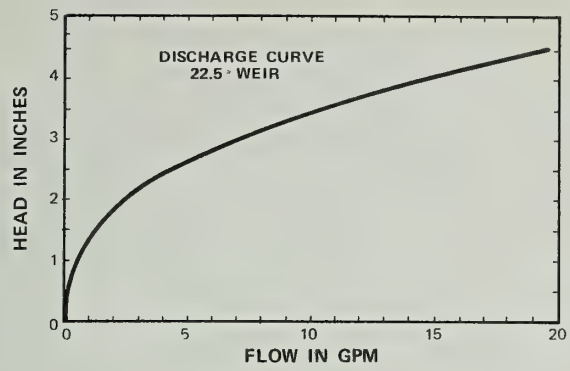
ATTACHMENT 3

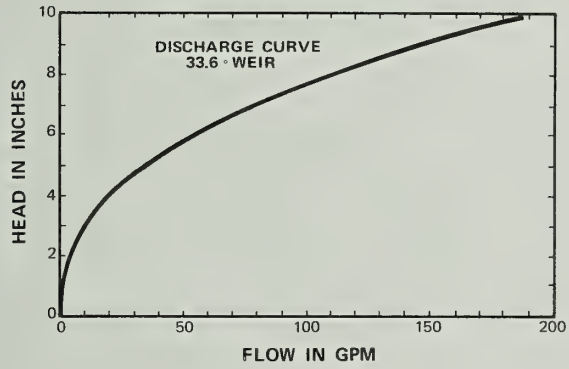
LIST OF CHEMICAL SUPPLIERS

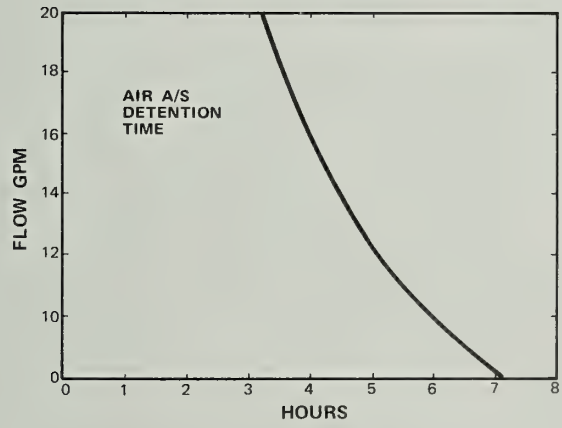
Aluminum sulfate Liquid sodium hypochlorite Sodium nitrate	McKesson Chemical Company 33950 7th Street Union City, California 94587 415 489-1400
Carbon dioxide	Firemaster 1580 Indiana Street San Francisco, California 94107 415 285-5700
Sodium nitrate Copper sulfate Sodium hydroxide	Van Waters & Rogers 3745 Bayshore Boulevard Brisbane, California 415 467-2600
Lime (calcium hydroxide)	Flintkote Company U.S. Lime Division 125 12th Street Oakland, California 415 839-2092
Polymer	Dow, Nalco, Cyanamid, Calgon

ATTACHMENT 4

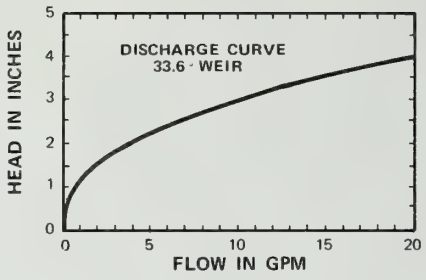
MISCELLANEOUS FLOW GRAPHS

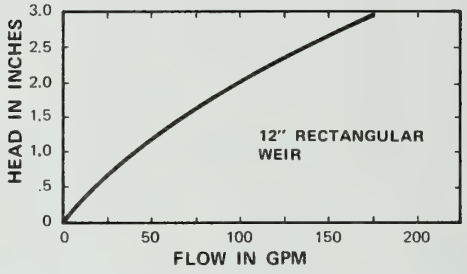


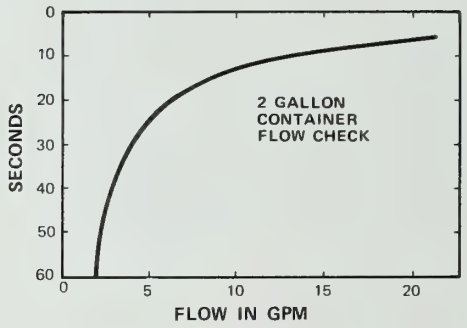


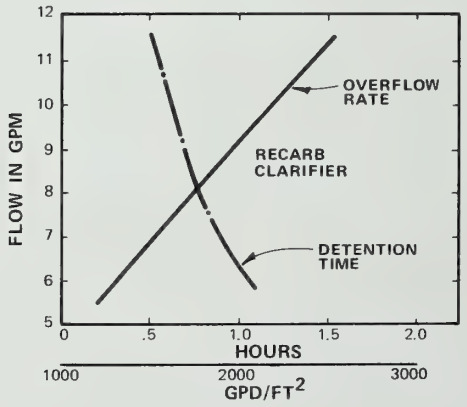


ATTACHMENT 4
SHEET 1 OF 2









ATTACHMENT 4
SHEET 2 OF 2

ATTACHMENT 5

FILTRASORB INSTRUCTION MANUAL

CALGON
CORPORATION

SUBSIDIARY OF MERCK & CO., INC.

Pilot Filtrasorb System

INSTRUCTION MANUAL

Code #N-5-092

701118JL

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1. INTRODUCTION

1.1 DETERMINATION OF DESIGN PARAMETERS FOR A FILTRASORB SYSTEM

If the adsorption isotherm analysis on a waste water sample proves to be feasible in terms of capacity and removing of dissolved organics, the next step in the total study is to determine accurate carbon exhaustion rates and contact time by performing column studies. The column studies can determine several parameters that might have been questioned during the preliminary adsorption isotherm study. Several items of importance that will be analyzed during the column studies are listed as follows:

1.1.1 The determination of an accurate capacity of the carbon to adsorb the particular organics from the waste water.

1.1.2 The determination of the depth of the adsorption zone and total organic carbon wave front profiles which are developed from the column test data. These curves will give a fair estimate of the carbon depth needed to perform the desired function based on the objectives that this system must achieve.

1.1.3 To determine the effect of solids on the activated carbon column system. These observations may suggest that colloidal suspended solids would have to be stabilized and removed from the system prior to applying the water to the carbon columns. Suspended solids in the waste water could also have an adverse effect on the carbon by causing severe clumping.

In this particular case, pretreatment methods may also be examined. The observations could also point out that there would be really no need to go into any expensive pretreatment because the filterability of the granular activated carbon could do the job quite effectively without changing the operating costs drastically.

1.1.4 If the waste being treated is a municipal waste water, there will no doubt be biological activity in the columns. Observations of any by-products from the biological growth on the columns could be beneficial to design. An example could be to determine how hard or how easy the biological suspended solids can be removed from the columns.

1.2 A pilot activated carbon column study is quite a delicate operation. Because of this any difficulties that will be encountered will usually be magnified during the column study. Therefore, any problems encountered, solved and noted will usually be a real asset to the design of the waste water treatment system developed from the data.

2. APPLICATION OF PILOT FILTRASORB SYSTEM

2.1 SAMPLING AND ANALYSIS FORMAT FOR COLUMN TEST RUNS

To obtain reliable data from a column test run, a procedure to sample and analyze waste water being treated should be followed systematically. The steps which are to follow will outline this general procedure:

2.1.1 Sampling should be at the influent to the columns and the effluent of every column on-stream.

2.1.2 Sample frequency should be every four hours. A composite of the six samples taken each day, should be made each day. Deviation from sampling every four hours is acceptable; however, the exactness of the test results will be reduced. Where waste water concentrations are quite high it may be necessary to sample more frequently than four hours. In these cases it may be desirable not to composite over a day period. This can be left to the judgment of the engineer in charge.

At times it may be desirable to ship the composite samples to the Calgon laboratory for a TOC analysis. Sample vials for this purpose should be obtained from Calgon laboratories. Before shipping, these vials should have the pH adjusted to a value of 2.0 using H_2SO_4 (sulfuric acid). This will prevent any biological degradation of the samples while in shipment. Insert aluminum foil under the vial cap before installing the cap.

All the sample vials received from Calgon laboratories will have a "Waste Water Tag" attached by a rubber band. Each vial will also be encased in foam rubber. Before a vial is sent back to Calgon laboratories, the following should be done:

A. Clearly mark the "Waste Water Tag" indicating the analysis to be run, name of company or plant and date.
B. Attach the "Waste Water Tag" using the rubber band. A vial without a tag is of no value.
C. Completely encase the jar in foam rubber.
D. USE CARE IN PACKAGING! Poor packaging leaves many samples broken upon arrival at Calgon Laboratory.

2.1.3 The flow rate through the columns should be checked at least once per day using a timer and a fixed volume container. An example would be to use a one-liter graduated cylinder and a watch. For typical flows used in a column test the results are:

0.25 gpm flow rate - 64 seconds/liter
0.5 gpm flow rate - 32 seconds/liter

2.1.4 The easiest method to analyze the samples taken from a column test run would be tc use the TOC (Total Organic Carbon) analysis. However, COD (Chemical Oxygen Demand), BOD_5 (Biochemical Oxygen Demand - 5 day) or color can be used to analyze the composite samples taken from the columns. The latter tests take more time and have a larger percentage error than the TOC analysis so are not recommended for the analysis on the composite of the influent and of all columns every day.

The TOC analysis is recommended because it does give an indication of the organic carbon in the waste water. Since the adsorption is of the organics in the waste water, the TOC test fits well in the overall analysis of the column test.

When the final results of the column tests are to be based on BOD_5, COD or color, then these tests can be run in conjunction with the TOC test on the influent and effluent from the columns. When this is the case, it is recommended that BOD_5 be run every three days, COD run every three days, and color every day on the influent and effluent sample.

Attached is a sample data sheet that can be used to log the data from a pilot test run. For a good test run all the flow and TOC data should

PLANT

COLUMN TEST DATA SHEET

DATE	FLOW RATE (gpm)	ACCUM. FLOW gal/day	TOC mg/l					BOD_5 (mg/l)		COD (mg/l)		COLOR (APHA)	
			Inf.	No. 1	No. 2	No. 3	No. 4	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.

be complete for each day of the test. The BOD_5, COD, color, and other data points are to be filled in as it is necessary. Should the plant doing the test work prefer the BOD_5, COD or color tests, these parameters can be substituted for TOC values on the data sheet.

Any problems encountered in the application of the Filtrasorb or this system should be forwarded to the Filtrasorb Department at Calgon Center, Pittsburgh, Pennsylvania.

2.2 APPLICATION TROUBLESHOOTING:

2.2.1 PROBLEM

An abnormally high effluent COD.

2.2.1.1 A system that has run for several days may develop a bacteria growth on the carbon much the same as with a trickling filter. If this is the case and the system goes anaerobic, a solution containing methane and hydrogen sulfide could be discharged. The result would be a higher than normal COD on the effluent.

2.2.1.2 Inorganics demanding oxygen could also produce a higher than normal effluent COD.

2.2.2 SOLUTION

2.2.2.1 In the case of where a system could have gone anaerobic causing methane and hydrogen sulfide to be discharged, a simple backwashing of the

column will alleviate the problem. To be sure that this does not occur again, the columns should be backwashed once every 24 hours.

2.2.2.2 To be sure that inorganics are not causing a high COD problem, the influent stream should be checked for inorganics that could demand oxygen.

2.2.3 PROBLEM

Biological growth in the columns.

2.2.3.1 In waste waters which have an organic loading which is readily biodegradable, a biological growth will develop after a few days of operation. The result of the biological growth will be an accumulation of biological solids in and around the granules of activated carbon. If these are not removed periodically, the results will be a clumping and clogging of the filter.

Biological floc growing around the granules of activated carbon will also entrap some colloidal suspended matter which normally might pass right on through the filter media. The overall effect is not known, although adverse conditions could exist from this. In addition, a green algae may appear in the columns due to the action of sunlight on the dormant spores in the waste water.

2.2.4 SOLUTION

2.2.4.1 To reduce the amount of biological solids growing in and around the granular activated carbon, the columns should be backwashed periodically. The backwashing may not necessarily destroy the biological growth but will keep it under control so that the solids system will not be objectionable. Keeping the biological floc under control will also prevent slough-off of biological solids into the effluent giving a turbid discharge from the pilot columns.

2.2.4.2 Algae growth is easily controlled by shielding the columns from sunlight. This may be done by covering columns while outside or moving them inside.

2.2.5 PROBLEM

Suspended solids carrying through the columns.

2.2.5.1 Suspended solids will appear on the influent from any of the columns due to biological activity on the columns or a carrythrough of colloidal suspended materials.

2.2.6 SOLUTION

2.2.6.1 The problem with suspended solids in the effluent of the columns is due to biological activity in the columns. It will be readily visible by viewing the columns. If it is apparent that there is a biological growth on the columns and the results are giving a high suspended solids level on the column effluents, then the columns should be

backwashed for at least 10 minutes. This backwashing will free the solids from the granules of carbon and slow the biological growth to the point of where the solids carry over and effluent from the columns will be at a minimum.

2.2.6.2 If the solids that are passing through the filters are colloidal in nature, they will not be removed by the granular activated carbon. These solids can only be handled by properly pretreating the waste water. This can be determined by jar testing the waste water and determining the proper coagulant and/or coagulant aid needed to clarify the water.

3. FOUR COLUMN SYSTEM INSTRUCTIONS - 387359

3.1 DESCRIPTION

The four column unit is supplied mounted on a sturdy free standing steel frame and is completely piped prior to shipment. A supply of 1/2" OD tubing is supplied for connecting to the sample input, sample output and the backwash drain. In addition, a standard male hose connector is supplied on the backwash inlet to facilitate connecting to a water faucet.

3.2 UNPACKING

Examine the unit carefully for any damage which may have occurred in shipment. If any damage is noted, a claim should be filed with the carrier. Calgon will be glad to assist in any way by providing repair estimates, etc.

3.3 STARTUP AND OPERATION

3.3.1 The Filtrasorb carbon must be soaked in water overnight before the system can be used. This can be done before or after the carbon is added to the columns.

3.3.2 Remove the top flanges from each of the columns, check to see that the distribution plate is properly located above the discharge part of each column. This plate is a perforated disc designed to allow a uniform distribution of flow through the column.

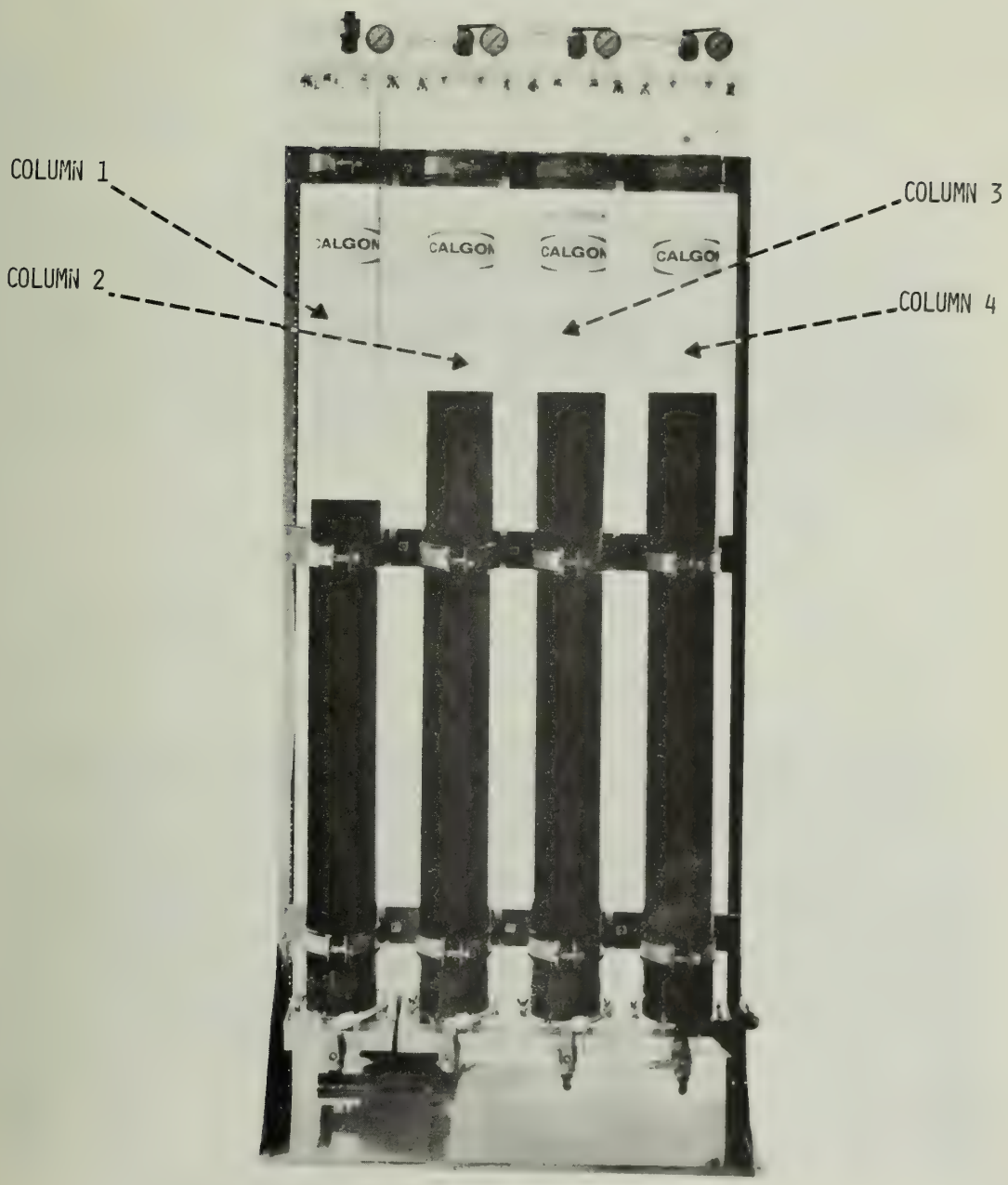
3.3.3 Close the 3-way and 2-way valves at the bottom of the assembly. Refer to Figures 2b, 3 and drawing 287407.

3.3.3.1 Fill each column one-half full of water.

3.3.4 Add 3-4 inches of "pea-size" stones to the column above the distribution plate. (Commercial grade "shot gravel" is ideally suited for this application.) These stones will further ensure a uniform flow distribution.

3.3.5 Prepare a carbon-water slurry which will facilitate adding the carbon to the columns. This can be done by filling a bucket with carbon and slowly wetting it with water from a hose.

3.3.6 Add 3.5 feet of carbon to all four columns. Measure the heights to be sure accurate depths are known for future calculations of capacity.

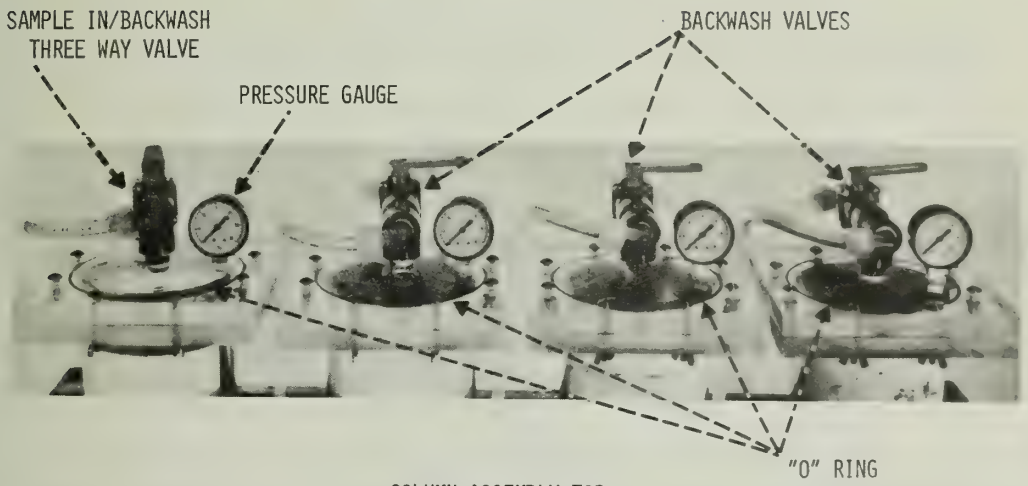


FOUR COLUMN STAND ASSEMBLY
FIGURE 1

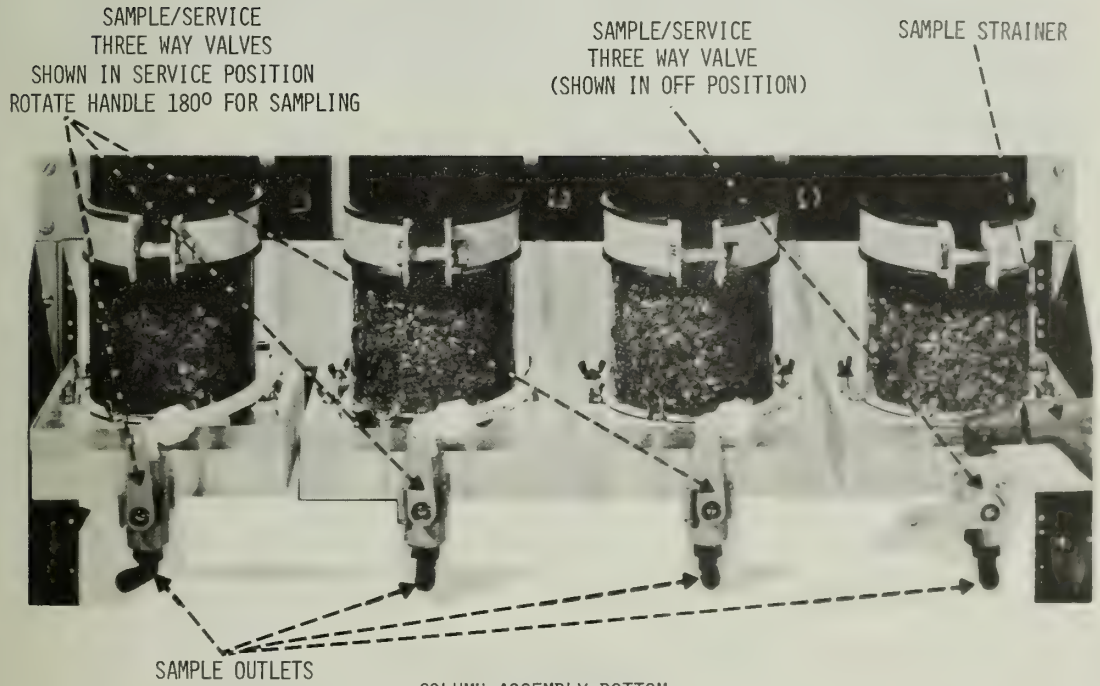
3.3.7 After all the carbon is in the columns, attach the top flanges and check for any leaks. At this time each column should be backwashed for at least 10 minutes. Refer to Figures 2A, 2B, 3 and 7 and drawing 287407 for the necessary valving arrangement. This is done to remove fines and to stratify the beds. Backwash with service (tap) water not waste water at a rate such that carbon is not carried out the discharge port at the top of the column. A 4 gpm flow control valve located in the backwash input line will help ensure a safe flow rate.

3.3.8 After the backwashing is complete and there are no leaks apparent, the unit is ready for operation unless the water soaking is being done in the columns. Then 24 hours must elapse before operation can begin.

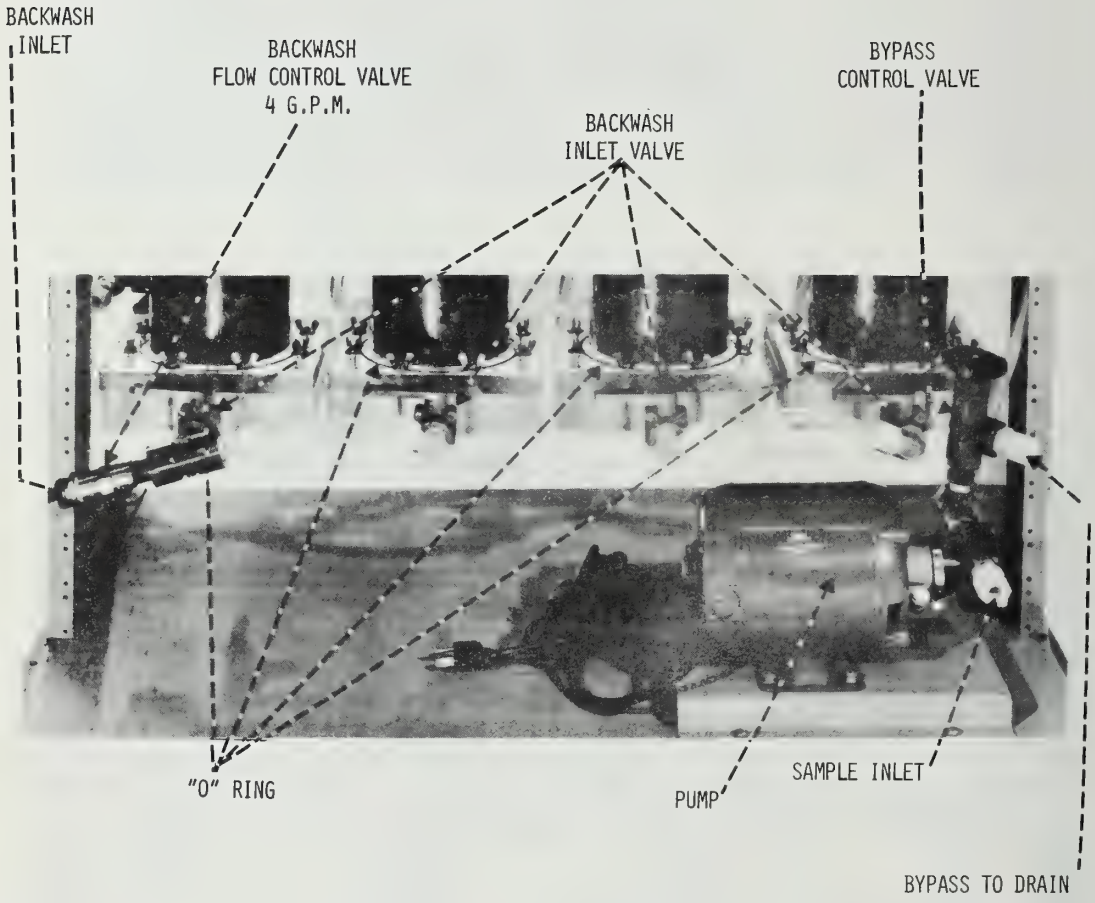
3.3.9 Position the valves for normal service operation. Refer to Figures 2A, 2B, 3 and 8 and drawing 287407. Start the feed pump and percolate waste water through the system. Check to make sure water is flowing through the pump. Damage to the pump can occur if it is run dry for more then 30 seconds. In order to achieve the goal of 0.5 gpm through the system, it will be necessary to set the pressure in Column No. 4 to 10-15 psig. This can be set by using the sample by-pass valve located in the pump discharge line. Because of possible suspended solids in Column No. 1, it will be necessary to set the pressure in Column No. 1 somewhat higher to achieve the 10-15 psig pressure in Column No. 4. Should the pressure drop in Column No. 1 rise above



COLUMN ASSEMBLY TOP
FIGURE 2A



COLUMN ASSEMBLY BOTTOM
FIGURE 2B



COLUMN ASSEMBLY BOTTOM REAR
FIGURE 3

10 psig, the column should be backwashed to remove the suspended solids collected.

In most cases the pressure drop between Columns Nos. 2, 3 and 4 should be negligible. The reason being that the water should be free of suspended solids after the filtering done in the first column.

3.3.1.0 The flow rate is controlled by a flow control valve located in the discharge line from Column No. 4. These valves will plug easily if foreign matter is allowed to pass through the columns. A strainer is installed just ahead of the flow control valve to trap any particles and prevent possible clogging. The strainer can be cleaned by unscrewing the cap as shown in Figure 9.

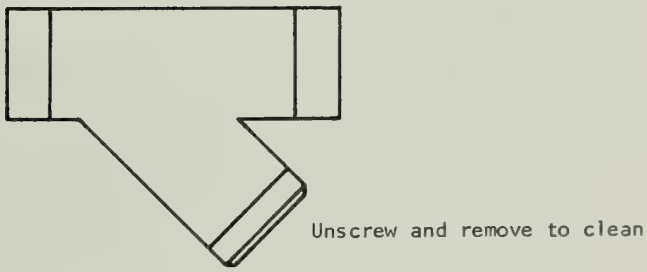
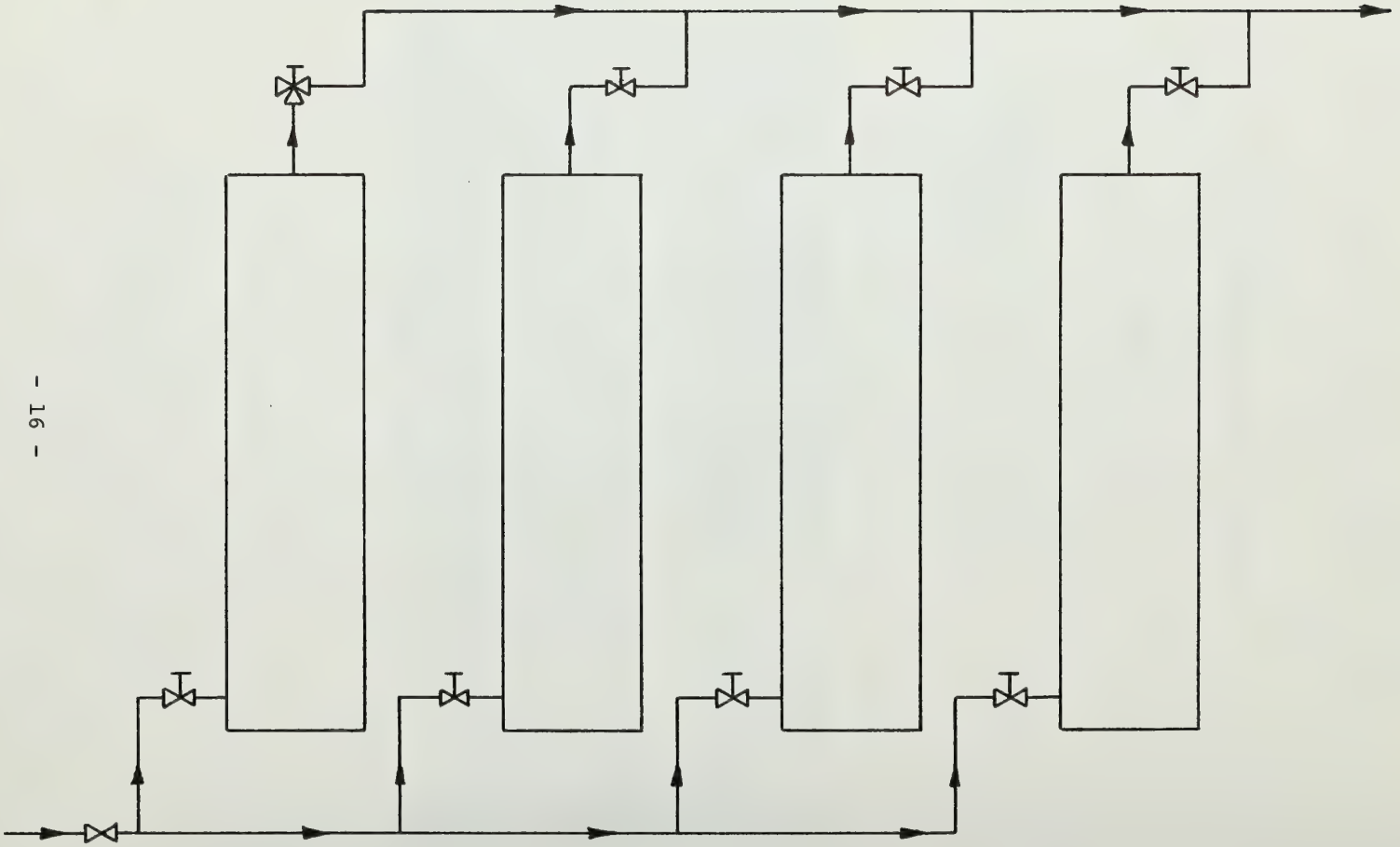
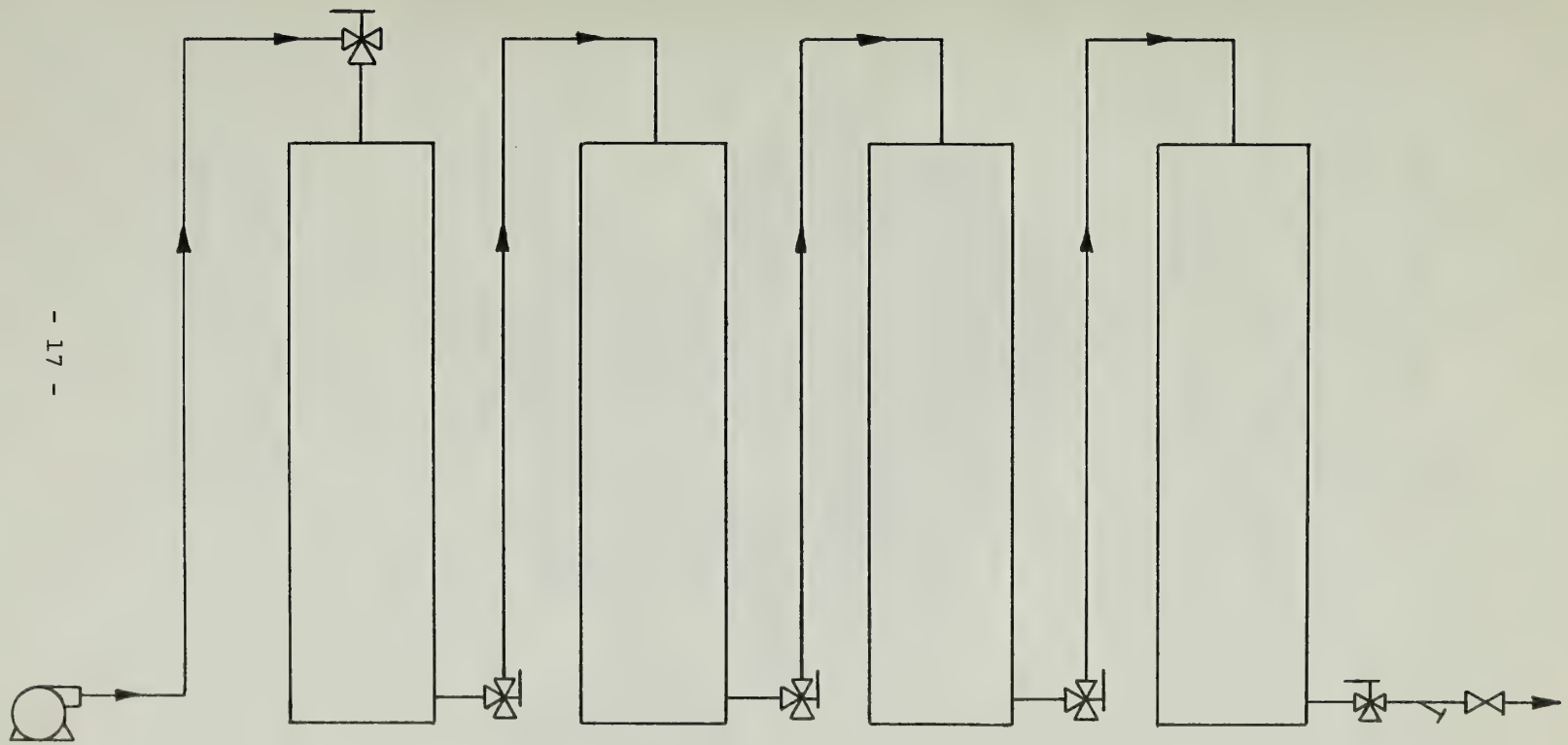


FIGURE 9



BACKWASH FLOW

FIGURE 7



SERVICE FLOW

FIG. 8

3.4 TROUBLESHOOTING (MECHANICAL)

If the unit does not function properly, first check to see that the valves are in their correct positions for the particular operation you are trying to accomplish. Many seemingly major problems can be caused by a closed valve, pump not plugged in, missing "O" ring in a flange, no sample supply etc., etc. A few minutes checking the obvious sometimes can save hours.

3.4.1 PROBLEM

Pump motor operates but does not pump water.

3.4.2 SOLUTION

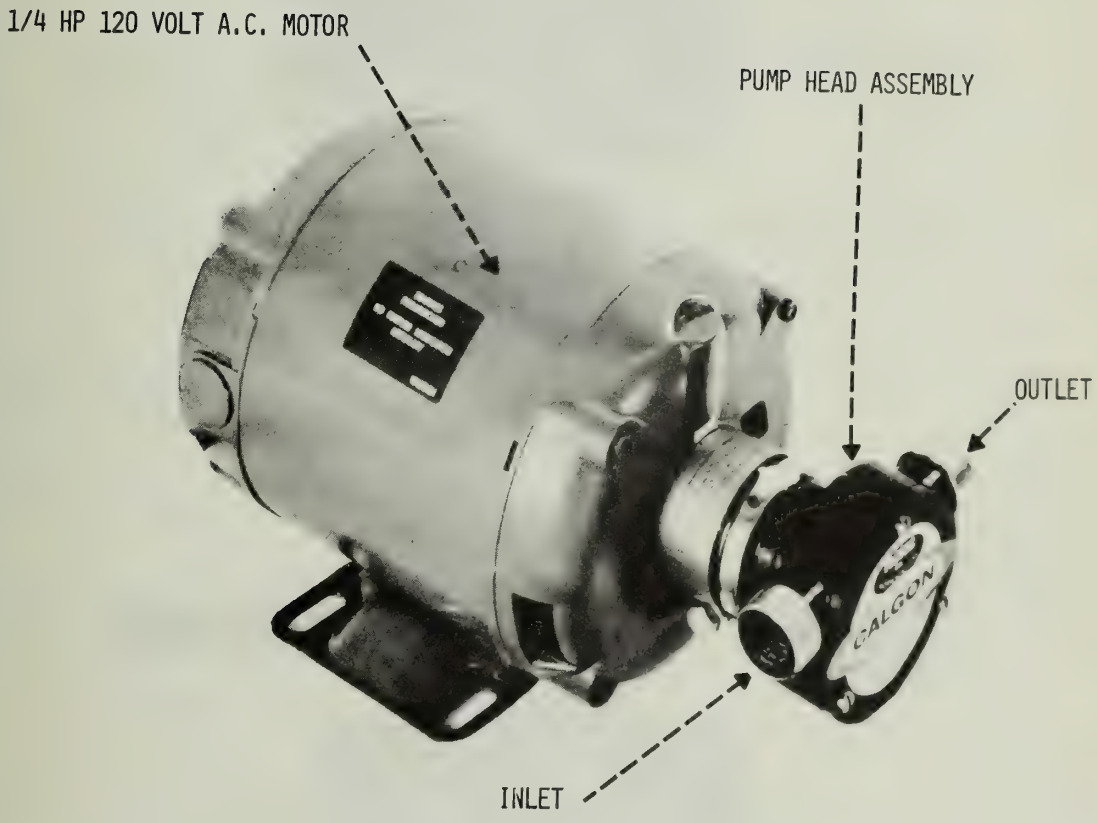
There are several possible causes for this problem. The water supply may be lost due to line plugging or inadequate supply. If possible, locate the suction line in a portion of the stream where the velocity is high enough to prevent solids from settling at the pump suction line.

3.4.3 PROBLEM

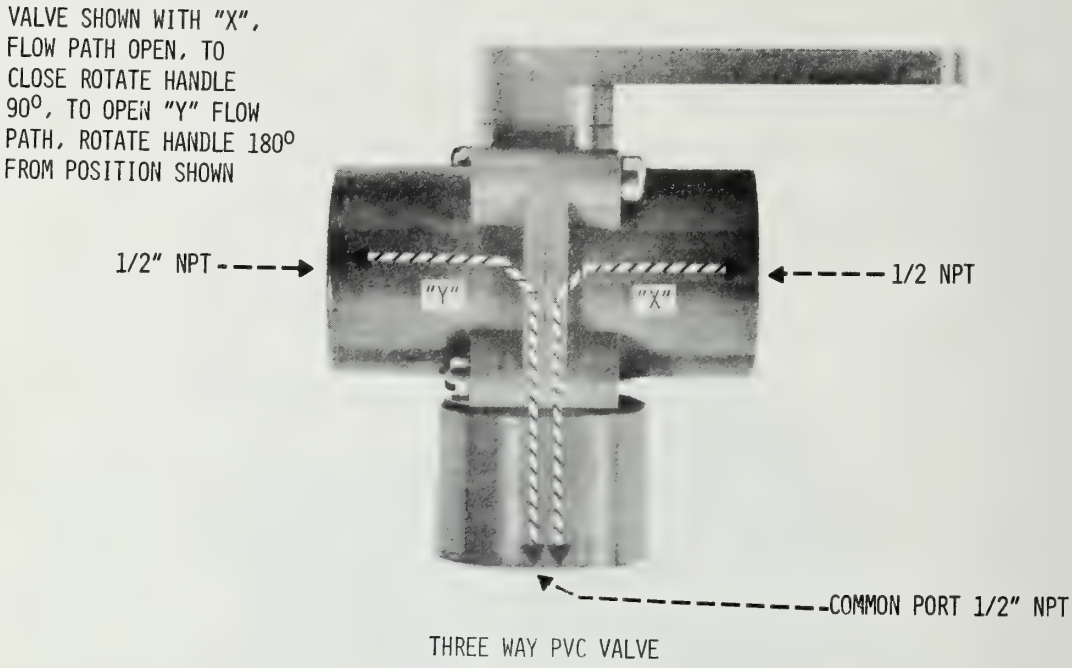
Carbon beds draining leave activated carbon exposed to atmosphere. This tends to pack the bed leaving channels in and around the carbon. The results will be a channelling effect in the column as the waste water runs through.

3.4.4 SOLUTION

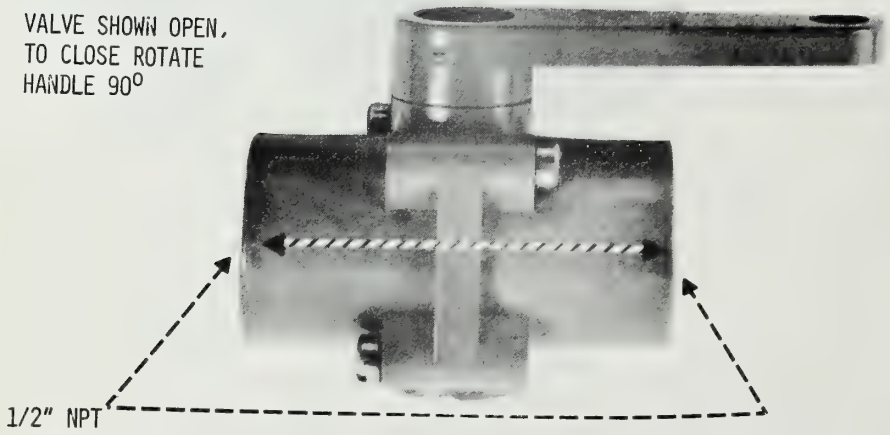
Whenever the carbon column is drained to a point where carbon is exposed to atmosphere, the column must be backwashed for 10 minutes.



SAMPLE PUMP
FIGURE 4


VALVE SHOWN WITH "X", FLOW PATH OPEN, TO CLOSE ROTATE HANDLE 90°, TO OPEN "Y" FLOW PATH, ROTATE HANDLE 180° FROM POSITION SHOWN
1/2" NPT
"Y"
"X"
1/2 NPT
COMMON PORT 1/2" NPT

THREE WAY PVC VALVE



TWO WAY PVC VALVE
FIGURE 5

The backwashing will tend to loosen packed sections and will stratify the bed to its original position.

3.4.5 PROBLEM

High pressure differential (drop) across a column or columns.

3.4.5.1 Usually the problem causing a high pressure differential is suspended solids in the influent to the columns. This will typically show up in a high pressure differential across Column No. 1.

3.4.5.2 High pressure differential can also be caused by a restriction in the strainer in the sample outlet line.

3.4.5.3 Other potential problem spot where clogging could occur is at the discharge port of any of the columns.

3.4.6 SOLUTIONS

3.4.6.1 If the problem is due to suspended solids in the first column, the solution would be to backwash that column for at least 10 minutes with service water.

3.4.6.2 If the problem is a clogged strainer, the pressure in Column No. 4 will be essentially the same as the pressure in Column No. 1 and very little, if any, flow will be coming out the discharge line. The strainer is easily cleaned as described in Part 3.3.1.0, Page 14, Figure 9.

3.4.6.3 If the high pressure drop is due to clogging in any of the other columns in the system, the trouble can be localized by following the pressures on the top of the columns through the system. For instance, if the pressure on the top of Column No. 3 is the same as the pressure on the top of Column No. 1 and the pressure on the top of Column No. 4 is much lower, it can be assumed that there is plugging in Column No. 3 or its discharge port. These plugs can only be found and corrected by removing piping and further checking.

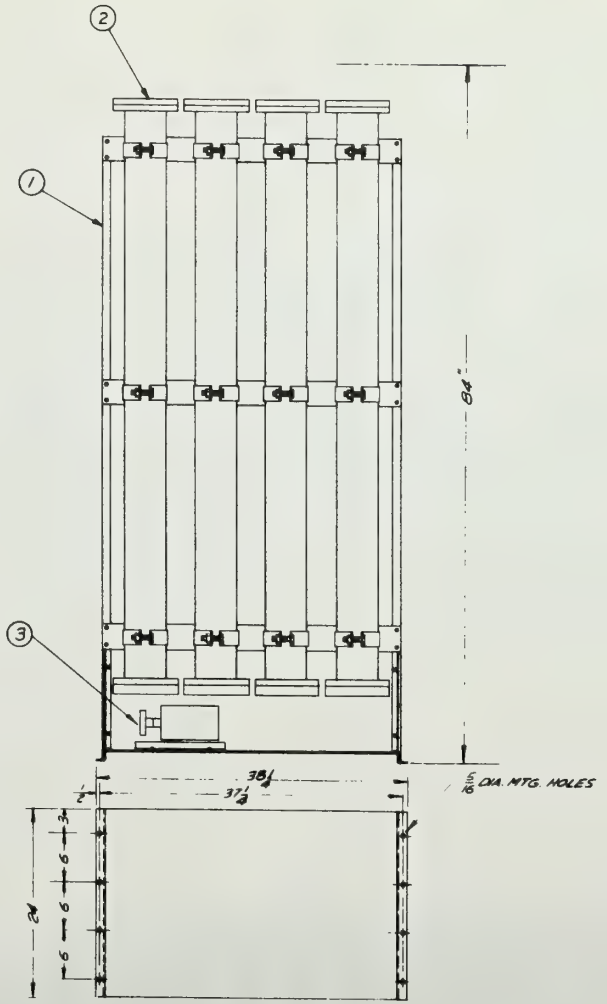
SPARE PARTS

FOUR CARBON COLUMN SYSTEM

CATALOG NO.	DESCRIPTION
3500-8600-5	"O" Ring, Column Flanges 6 x 6-1/4 x 1/8
*3500-8619-6	"O" Ring, Column Flanges 6 x 6-3/16 x 3/32
3500-8601-3	Pump (Complete With Motor)
3500-8602-1	Pump Service Kit
3500-8603-0	Pump Head Assembly
3500-8604-8	Pump Impeller
3500-8605-6	Pump "O" Ring
3500-8606-4	Flow Control Valve 1/2 gpm
3500-8607-2	Flow Control Valve 4 gpm
3500-8608-1	Pressure Gauge
3500-8609-9	3-Way PVC Ball Valve
3500-8610-2	2-Way PVC Ball Valve
3500-8611-1	1/2" OD Polyethylene Tubing
3500-8612-9	Polypropylene Elbow 3/8 NPT x 1/2 Tube
3500-8613-7	Polypropylene Male Connector 1/2 NPT x 1/2 Tube
3500-8614-5	Polypropylene Elbow 1/2 NPT x 1/2 Tube
3500-8615-3	Polypropylene Male Branch Tee 1/2 NPT x 1/2 Tube
3500-8616-1	Column Tube
3500-8617-0	Column Top Flange
3500-8618-8	Column Bottom Flange
*3500-8620-0	PVC Reducing Bushings 1/2 x 3/8 NPT
*3500-8621-8	PVC Close Nipple 3/8 NPT

*These parts are used on units with no suffix letter in the serial number.

387359



LEGEND

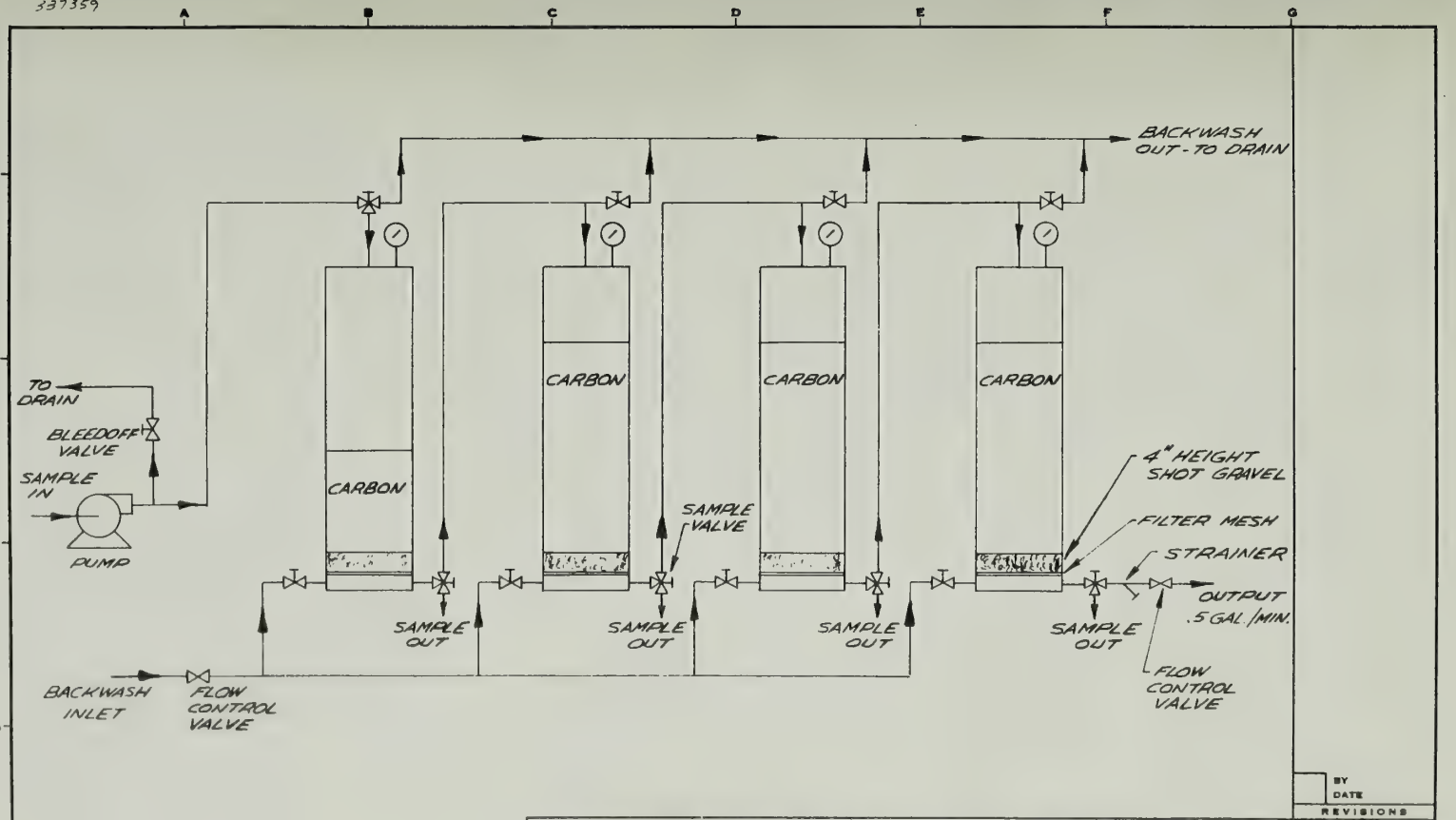
1 CARBON COLUMN PANEL STAND
2 CARBON COLUMN
3 PUMP

SPECIFICATIONS

SAMPLE INPUT - 2 G.P.M. NORMAL
MAX. COLUMN PRESSURE - 30 PSIG
BACKWASH FLOW - 4 GPM NORMAL
PUMP ELECTRICAL REQUIREMENTS - 120 VAC 60Hz

SCALE 1/4					CARBON COLUMN PANEL STAND OUTLINE
DR HEY	CHKD EJT	APP WJL	MFG		CALGON CORPORATION PITTSBURGH, PA.
DATE 10-26-70	DATE 11-12-70	DATE 11-12-70	DATE		CODE 387379

BY
DATE
REVISIONS



BY
DATE
REVISIONS

UNLESS OTHERWISE SPECIFIED USE

SCALE	DIM. BOUND	FRACTIONS DIM.	ANGLES	BREAK CORNERS .005 - .010 R
~	✓	±	±	

DR. RAH	CHKD. [illegible]	APP. WRL	MFG.
DATE 11-6-70	DATE 11-12	DATE 11-12-70	DATE

TITLE: SYSTEM DIAGRAM FILTRASORB COLUMN

CODE

CALGON CORPORATION
PITTSBURGH, PA.

DWG 287407

PRINTED IN U.S.A.

FORM 5315

APPENDIX H

APPENDIX H
LABORATORY REPORTS

Appendix H-1

Pilot Centrifuge and Furnace Test for CH2M HILL, San Francisco Pilot Plant, Job 2013. Envirotech Systems, Inc., Laboratory Report, November 16, 1973.

Appendix H-2

Pilot Centrifuge and Multiple Hearth Furnace Incineration Test Conducted for the Consulting Firm of CH2M HILL on Lime Sludge from the CH2M HILL Pilot Plant. Envirotech Systems, Inc., Laboratory Report, March 1974.

Appendix H-3

Laboratory Study on the Effects of Chemical Coagulants on Anaerobic Digestion of Richmond-Sunset Sludge. James M. Gossett and Perry L. McCarty, Consultant, Stanford, California, April 1974.

Appendix H-4

Phase II Report of Laboratory Study on the Effects of Chemical Coagulants on Anaerobic Digestion of Richmond-Sunset Sludge. Perry L. McCarty, Consultant, Stanford, California, August 1974.

APPENDIX H-1

ENVIROTECH SYSTEMS INC.

LABORATORY REPORT

PILOT CENTRIFUGE AND FURNACE TEST

FOR CH_2M/HILL

SAN FRANCISCO PILOT PLANT

JOB 2013

Tom Carleson
November 16, 1973

ENVIROTECH

November 20, 1973

Mr. Jerry Wilson
CH_2M/Hill Consulting Engineers
360 Pine Street
San Francisco, California

Re: San Francisco Pilot Plant
Southeast Plant Lime Sludge Testing

Dear Jerry:

After altogether too much delay, we've prepared the report on the lime sludge test work for the Southeast plant. I hope you can appreciate the reason for the delay by glancing at the amount of data contained in the report.

The sludge was extraordinarily tough to work with. Various conditions were tested in the two-stage centrifugation, single-stage centrifugation and recalcining phases of the study.

The major conclusion drawn is that reclamation of the lime from the Southeast sludge as sampled and tested does not appear practical. However there are several reasons why testing should continue:

1) Proper modes of operation have been better defined for centrifuge and furnace operation. Another run might be more successful.

2) The dry ash classification step, after the furnace, was not available during this test. As we discussed, it should improve the product significantly. We have saved the ash so that we can run it through the classifier when possible.

3) Whatever the inhibitory material is in the sludge it is not affecting the air discharge. The Bay Area requirements are being met.

Judging by the "fluffiness" of the sludge, the degree of difficulty in de-watering and calcining and the special discharge analysis on metals that was conducted, it would appear that the seawater intrusion is responsible for the sludge problems. This may not be, but the signs point in that direction. If it is possible this seawater problem may be averted in the future, it would be well to look at the sludge further.

All in all, it was the most difficult sludge we've worked with and was very unusual for a lime sludge. Based on the results of this first run recalcining of the sludge mixture tested would not be advisable, however further testing under modified test and sludge conditions will tell us more.

Municipal Equipment Division, Envirotech Corporation, 100 Valley Dr., Brisbane, California 94005, Telephone (415) 467-3800, Telex 340-231

Hopefully, more positive results will be forthcoming by future tests.

Let me know if you have any questions.

Sincerely,

ENVIROTECH SYSTEMS INC.

Ted Zaferatos
Manager Sales Development
Municipal Thermal Systems

TZ:mlc

Enclosure

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I. Introduction

This report summarizes the results of the first of two lime sludge centrifugation and recalcination tests conducted for CH_2M/Hill Engineering firm. The lime sludge received was from the South East treatment plant at 1700 Gerrold Avenue, San Francisco. The flow diagram for the sludge generation and recalcination appears in Figure 1. The purpose of the project is the determination of the feasibility of two-stage centrifugation for classification of the calcium carbonate material and recalcination of the centrifuge cake from the first-stage centrifuge step. The first-stage of the centrifugation would produce a cake high in inerts and calcium carbonate as a result of operation at high feed rates and moderate recoveries. The effluent from the first-stage would be passed to a second stage centrifuge to collect the volatiles, magnesium and phosphate components at high recoveries.

The pilot facilities for this test included a Sharples T600 6" diameter solid bowl centrifuge and a BSP 30" inside diameter x 6 hearth furnace.

The T600 centrifuge has an adjustable bowl speed of from 0-6000 rpm capable of producing 0-3067 G in the 6" bowl. The scroll speed is also adjustable from 0-50 rpm. The pool depth is adjustable from a minimum setting of 1 to a maximum of 4. The ranges for full scale operation are 1800-2500 G and a scroll speed of 10-25 rpm.

The 30" inside diameter by 6 hearth multiple hearth furnace has approximately 25 ft^2 of effective hearth area. The material is fed into the first hearth and discharged from the sixth. There are two natural gas burners per hearth. Gases from combustion can be drafted from each hearth or any combination of hearths. The off gas system includes a dry cyclone for gross solids capture, an afterburner for residual combustibles oxidation, a wet scrubber for fine solids removal and an induced draft fan and stack. The arrangement of these items is depicted in Figure 2.

A total of two and a half days were spent operating the centrifuge and one day operating the furnace.

II. Test Operation

The centrifuge work was begun October 1, 1973. There were approximately 19 runs made under varying conditions of operation. These runs are summarized in Table 1. On the first day a high feed rate was used to determine the possibility of two-stage centrifuge classification. A low pond setting was used to provide high percent cake solids and a high feed rate was used to reduce clarification. Since the recoveries were so low in runs 1-7, polymer was added to improve the capture. The furnace feed was prepared from runs 14-19.

The furnace operating parameters appear in Table 3. The furnace atmosphere was adjusted for an oxidizing condition and controlled for a slightly negative pressure. The teeth on the rabble arms were adjusted to provide approximately 25 percent back rabbling or plowback of material in the hearths. The feed was screw fed into the first hearth and screw discharged out of the sixth. The exhaust gases were drafted out of the first hearth. The retention time was adjusted by adjusting the shaft speed.

After the furnace had reached stable conditions, stack gas sampling of the furnace off gas and the scrubber off gas was conducted. It should be recalled that the exhaust gas system included the dry cyclone, afterburner and wet scrubber.

III. Results

The operating condition and recoveries of total suspended solids and calcium carbonate, pounds of dry solids produced in the cake per hour, and pounds of polymer used per ton of dry solids appear in Table 1. The product analyses for several runs appear in Table 2.

The operating conditions for the furnace, product analyses, and results of muffle furnace work appear in Table 3.

The results of the stack gas testing and the Bay Area Air Pollution Control District allowable emission limits appear in Table 5.

The analytical procedures for the analyses appear in Appendix I.

IV. Discussion of Results - Centrifuge Run

The data on Table 1 and 2 and Graph 1 indicate that polymer addition will increase the percent recovery and the pounds of dry solids per hour production. The optimum conditions for recovery and dry solids production are: 3 gpm effluent rate, 9.7 scroll speed, polymer dose of 60 ppm. Under these conditions a recovery of 60%, cake solids of 17%, percent $CaCO_3$ of 65, 38 pounds of dry solids per hour and polymer requirement of 10 pounds per ton may be expected. Classification is increased as the flow rate is decreased and appears to be maximum around 1.64 gpm with polymer. The percent $CaCO_3$ in the cake increases from 65 to approximately 74. The gain in percent $CaCO_3$ of only 9% with a drop in dry solids production of 16 lbs/hour, from the optimum feed rate for recovery to the optimum rate for classification, is not much and indicates that classification operation would be inefficient. General classification operation produces a cake of 50% solids at a recovery of 50%.

Furnace Run

The results of the furnace run on Table 3 indicate that the material is difficult to recalcine. The low percent recalcined values indicate that there may be some refractory material in the feed which takes prolonged contact time to calcine. Normal furnace operation at 1800^{o}F, 60 minute retention time and 4 lbs/hr/ft^2 loading would produce a product recalcined 70% or more. Sufficient tests have been conducted to substantiate this. The refractory materials may be some materials which appear as $CaCO_3$ in the analyses but may be some acid soluble materials which are unrecalcinable and insoluble. Possible materials are: Calcium Metasilicate and Calcium Phosphate.

The furnace operation averages indicate that a feed rate of 100 lbs/hr (loading of approximately 0.8 pounds dry solids per hour per square foot) requires 13,400 cfh of natural gas, produces a product at a rate of 8% of feed rate and cyclone capture of 4% of feed rate.

A glance at Table 4 shows that the emissions from the scrubber were within the Bay Area Air Pollution Control District limits. The cyclone and wet scrubber captured 99% of the particulates. The afterburner oxidized approximately 88.6% of the combustibles. There are fairly high levels of silica and sodium in the particulates.

V. Conclusions and Recommendations

The following conclusions can be made from the test work:

1) Two-stage centrifugation is inadvisable due to the low recoveries and only slight beneficiation of the product.

2) Single-stage centrifugation with polymer at an effluent rate of 3 gpm is optimum for both solids recovery and dry solids production.

3) Furnace conditions of 0.8 lbs/hr/ft^2, 90 minute retention time and 1800^{0}F temperature were inadequate to completely recalcine the feed. With less than 50% of the feed $CaCO_3$ recalcined, recalcination of the sludge for reuse is inadvisable.

4) The furnace off gas system is adequate enough to meet air pollution requirements.

The following recommendations are made for the next test run:

1) Attempt two-stage centrifugation at effluent rates of 1.5-2.0 gpm with and without polymer. Use pond depth of 3 and scroll rpm of 9.7.

2) If two-stage centrifugation is again inefficient, centrifuge in one-stage for maximum recovery and solids production as indicated above.

3) Attempt to recalcine the cake from the centrifuge at varying loadings on the furnace from 0.5-1.0 pounds dry solids per hour per square foot under the condition described above.

4) Attempt acidification of the centrifuge feed to pH 9.5 to solubilize magnesium and produce better recoveries, dry solids rates and possibly allow two-stage work if time allows.

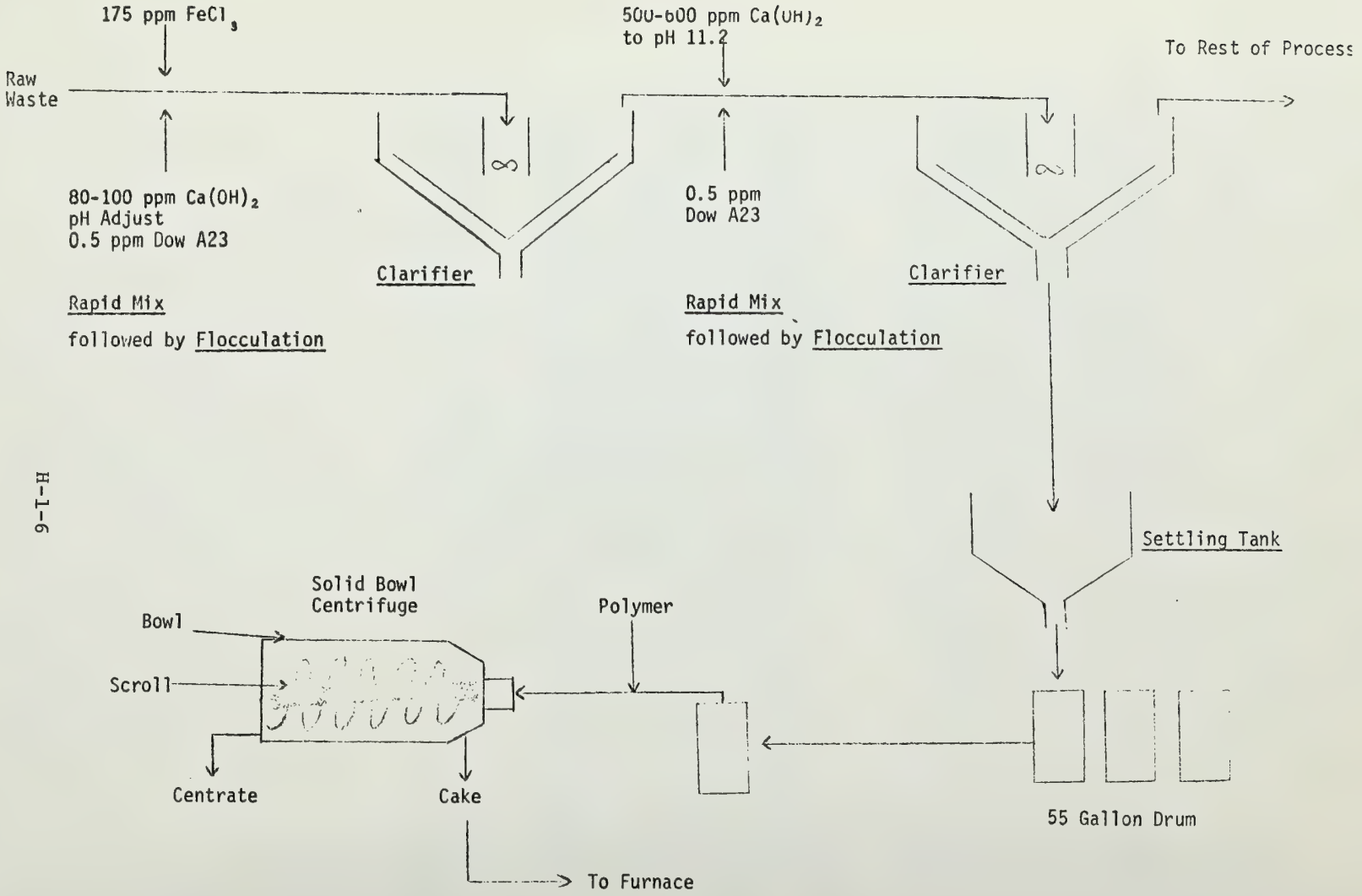
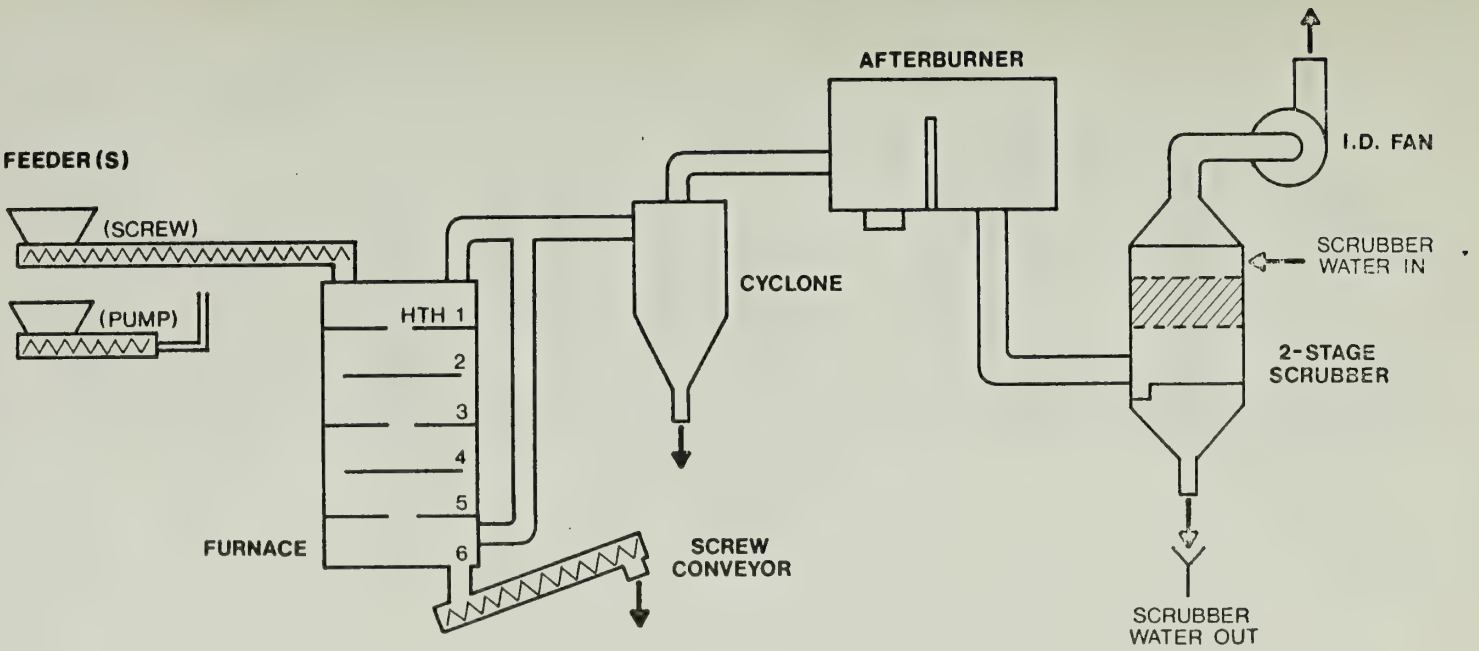


Figure 1 - Sludge Dewatering Flowsheet



30" I.D. x 6 HTH PILOT FURNACE SYSTEM

Figure 2 - Sludge Recalcination Flowsheet

TABLE 1

CENTRIFUGE OPERATING CONDITIONS AND RESULTS

10/1/73-10/3/73

Date	Run No.	Scroll RPM	Pond No.	Effluent GPM	Polymer[1] ml/min	Polymer[1] ppm	% Total Solids Effluent	% Total Solids Cake	% $CaCO_3$ In Cake	% Recovery[2]	% $CaCO_3$ Recovery[3]	Lbs. of Cake Dry Solids/Hour[4]	Lbs. of Polymer/Ton of Dry Solids[5]
10/1/73	1	9.7	1	5.19	-	-	4.2	50.0	75	2.7	3.6	2.8	-
	2	9.7	1	5.19	-	-	4.0	48.6	76	8.0	10.8	8.6	-
10/2/73	3	25.5	4	1.46	-	-	2.9	14.1	-	42.7	-	14.7	-
	4	9.7	4	1.66	-	-	2.9	17.8	71	40.7	51.6	15.3	-
	5	9.7	4	3.00	-	-	3.3	25.0	-	28.1	-	18.1	-
	6	25.6	4	2.72	-	-	3.2	15.7	-	33.5	-	20.6	-
	8	9.7	4	1.12	545	128.5	0.3	17.3	57	98.9	100	26.0	5.55
	10	9.7	4	2.89	643	58.8	2.2	17.4	-	58.4	-	37.9	4.49
	11	9.7	4	2.92	743	67.2	3.2	18.5	68	32.3	39.2	19.5	10.09
	14	9.7	3	3.33	643	51.0	3.4	23.0	62	25.7	28.4	16.7	10.20
	15	9.7	3	3.40	863	67.0	3.2	20.3	-	31.8	-	22.2	10.30
	17	9.7	3	1.64	643	103.5	1.2	18.8	-	80.5	-	29.6	5.75
	18	9.7	3	1.64	545	87.8	1.7	18.7	74	69.5	91.8	21.4	6.75

NOTES: [1]Polymer used was Percol #726 high anionic (Harrisons & Crossfield, Inc.) strength: 10g/10l

[2]$\%\ \text{Recovery} = \frac{(\%\ \text{TS of Cake} - \%\ \text{TDS})}{(\%\ \text{TS of Feed} - \%\ \text{TDS})} \frac{(\%\ \text{TS Feed} - \%\ \text{TS Effluent})}{(\%\ \text{TS Cake} - \%\ \text{TS Effluent})} \times 100$, % TDS = 0.24, % TS Feed = 4.3

[3]$\%\ CaCO_3\ \text{Recovery} = \frac{(\%\ CaCO_3\ \text{in Cake})}{(\%\ CaCO_3\ \text{in Feed})}$ (% Recovery), % $CaCO_3$ in Feed = 56

[4]Lbs. cake d.s./hr. [Where Feed Rate = Effluent Rate $\frac{(\%\ \text{TS Cake} - \%\ \text{TS Effluent})}{(\%\ \text{TS Cake} - \%\ \text{TS Feed})} \simeq$ [Effluent Rate - Polymer Rate]

gpm x 60 min./hr. x 8.34 lb./gal. x $\frac{(\%\ \text{TS Feed} - \%\ \text{TS Effluent})}{(\%\ \text{TS Cake} - \%\ \text{TS Feed})} \left(\frac{\%\ \text{TS Cake}}{100}\right)$

[5]Lbs. of Polymer/Ton Dry Solids

=Ml/Min Polymer x 1 mg/ml x 60 min./hr. x lb./453,000 mg x 2000 lb./ton x 1/lbs. Cake d.s./hr.

Graph 1
Centrifuge Performance

% Recovery Basis
Versus Effluent GPM

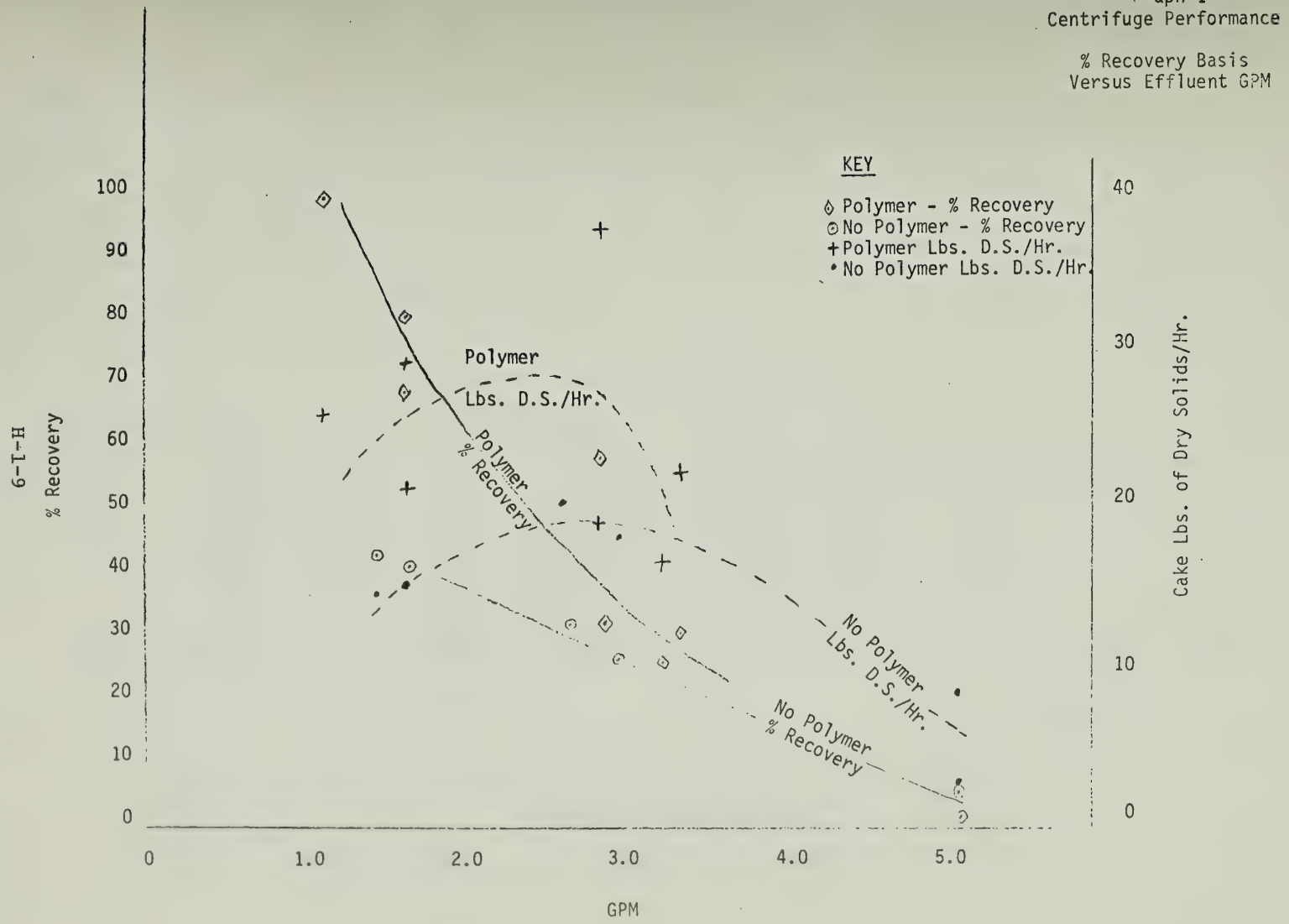


TABLE 2

RESULTS OF CENTRIFUGE RUNS

		Cake						Effluent		
	Run #	% TS	% VS	% CaO	% $CaCO_3$	% MgO	% P	% TS	% VS	% P
H-1-10	1	50.0	7.4	2.8	75	-	0.09	4.3	24.2	0.24
	2	48.6	7.3	3.4	76	-	0.10	4.1	24.2	-
	4	17.8	15.1	5.2	71	14.8	0.04	2.9	-	-
	8	17.3	19.6	5.6	57	23.6	-	0.3	-	0.24
	11	18.5	17.1	4.8	68	21.2	0.02	3.2	21.8	-
	14	23.0	15.5	5.6	62	13.6	-	3.4	-	-
	18	18.7	18.3	5.6	74	20.4	-	6.6	-	0.23
	Furnace Feed	20.3	18.7	7.7	64	23.1	0.05	-	-	-

NOTE: Feed to Centrifuge: 4.3% TS, 23.3% VS, 7.6% CaO, 56% $CaCO_3$, % MgO, 0.08% P.

TABLE 3

FURNACE OPERATING CONDITIONS AND RESULTS

Time	Retention Time (Min.)	Feed Rate Lbs./Hr.	Hearth Temperatures #1	#2	#3	#4	#5	#6	Natural Gas Usage Total cfh	Afterburner cfh	Discharge Rates Product Lbs./Hr.	Cyclone Lbs./Hr.	Comments
10/3/73 8:10 A.M.	60	100	1120	1780	1820	1800	1820	1800	-	-	-	-	Started Feed
9:10	60	100	500	1800	1800	1820	1840	1800	9630	310	-	-	-
10:30	60	100	720	1820	1860	1800	1840	1800	12750	1500	-	4.1	-
11:30	60	100	600	1760	1820	1800	1820	1800	13540	-	-	-	-
12:30	60	100	660	1800	1800	1800	1800	1800	24160	860	-	1.7	Product
1:30	60	100	660	1760	1780	1800	1800	1800	-	850	7.5	-	
3:30	60	100	900	1820	1840	1800	1820	1800	14110	1690	7.5	2.7	
7:30[1]	90	100	700	1800	1820	1840	1850	1840	13825	3300	6.2	0.9	Stopped Feed
Totals -	-	1133 lbs.	-	-	-	-	-	-	151,870 c.f.	8810 c.f.			
Averages -	-	100	-	-	-	-	-	-	13,400 c.f.h.	777 c.f.h.	54 Lbs.	27.5 Lbs.	
											7.7 Lbs./Hr.	3.9 Lbs./Hr.	

NOTE: [1]Changed retention time to 90 minutes at 4:30.

Time	% TS	% Vol.	% CaO	% $CaCO_3$	% MgO	% P	% CaO	% $CaCO_3$	% MgO	% Available CaO	% Recalcined[2]
9:10	20.3	18.7	7.7	64	23.1	0.05	-	-	-	-	
1:30	-	-	-	-	-	-	22.2	53.5	22.6	24.9	36.6
7:30	-	-	-	-	-	-	25.2	41.5	29.9	31.1	41.6
Overnight at 1800°F							35	14	34.4	-	57.8

NOTE: [2]% Recalcined = $\frac{\text{Actual \% CaO Obtained}}{\text{Theoretical \% CaO Obtainable}} \times 100 = \frac{\text{\% CaO in Product } [100 - 0.44 \times \text{\% } CaCO_3 \text{ in Feed}]}{(\text{\% CaO in Feed} + 0.56 \times \text{\% } CaCO_3 \text{ in Feed}}$

TABLE 4

STACK GAS ANALYSIS

Analysis	Furnace Outlet A	Furnace Outlet B	Scrubber Outlet A	Scrubber Outlet B	Bay Area APCD Allowable Limits
Velocity fps	-	-	51.2	53.8	-
Duct Temperature, or	1310	1360	142	145	-
Flow, CFM	-	-	950	1000	-
Flow, SDCFM	-	-	670	710	-
% H_2O	26.7	23.8	17.7	15.5	-
% O_2 (D.B.)	9.8	8.6	15.8	16.6	-
% CO_2 (D.B.)	8.2	8.4	4.1	3.2	-
SO_x, ppm (D.B.)	-	-	0.3	0.7	300
NO_x, ppm (D.B.)	-	-	19	15	-
Grain Loading gr/SDCF	6.40	3.67	0.036	0.027	0.05
Lb/Hr Partiulates	-	-	0.21	0.16	-
Carbonyls, ppm	8.6	12.4	2.0	1.3	25
Hydrocarbons, ppm	7.1	7.0	1.2	0.7	25
Sample Time, Min.	60	60	60	60	-
Duration	13:10-14:10	15:00-16:00	13:10-14:10	15:00-16:00	-
Metals in Particulates as % Oxides =					
Ca	15	15			
Mg	20	15			
Si	3.5	2.5			
Na	1.0	1.5			
Fe	0.8	0.7			
K	-	0.5			
B	0.25	0.2			
Mn	0.07	0.08			
Ti	0.015	0.015			
Sr	0.015	0.015			
Ni	0.015	0.015			
Cr	0.015	0.01			
Cu	0.005	0.005			
Ba	0.003	0.002			
Pb	0.005	<0.005			
Zn	<0.1	0.1			
Al	0.1	0.08			

APPENDIX

% Moisture

Approximately 25 grams of material is weighed into a tared container to the nearest 0.001 gram. The sample is placed into an oven at 103° C overnight or until there is no weight loss. The sample is then withdrawn, allowed to air cool, placed in a dessicator, and weighed. The percent moisture is determined by dividing the weight loss of the sample by the sample weight and then multiplying the result by 100.

% Volatiles

Approximately 1.000 grams of the dry sample is placed into a tared, covered crucible. The sample is then placed into a muffle furnace at 600° C. for 15 - 20 minutes. The sample is then withdrawn and weighed. The percent volatiles is determined by dividing weight loss by the sample weight and multiplying the results by 100.

% Ignition Loss

Approximately 1.000 grams of the devolatilized sample is placed into a tared crucible. The sample is then placed into a muffle furnace at 950° C. for 20 minutes. The sample is then withdrawn and weighed. The ignition loss is determined by dividing the weight loss by the sample weight and then multiplying by 100.

% CaO

200 milligrams of the dry material[1] is weighed into a volumetric flask. Distilled water is added to the mark, a stirring bar added and the sample mixed for 15 minutes. A 50 ml sample is then withdrawn, 2 ml of 1N NaOH added and then two packets of Hach indicator Calver II. The sample is titrated with EDTA titrant (1 ml = 1 mg Ca as $CaCO_3$) until a sky blue color persists. The milligrams CaO as $CaCO_3$ equals the milliliters EDTA times 20. The percent CaO is determined by multiplying the milligrams CaO as CaCO3 by .56 and dividing by the milligrams dry sample.

% $CaCO_3$

200 milligrams of the dry material is weighed into a volumetric flask. 5 ml of 1:1 HCl is added and the flask swirled to dissolve

[1]Devolatilized or furnace product.

the calcium carbonate mixture. 100 ml of distilled water is added and 5 N HCl is added to neutralize the residual HCl. Distilled water is added to the mark. The resultant solution is then analyzed for calcium as $CaCO_3$ in the same manner as for % CaO above. The percent $CaCO_3$ is determined by dividing the milligrams calcium as $CaCO_3$ by the dry sample weight and multiplying the resultant by 100%. From this percent total calcium as $CaCO_3$, the percent CaO divided by 0.56 is subtracted to yield the percent $CaCO_3$.

% Available CaO

Sufficient dry sample is ground and passed through 100 mesh screen to yield approximately 0.50 grams is placed into a flask and 50 milliliters of boiling water added. The solution is boiled for 1 minute, cooled and 50 ml of sugar solution (33% by weight cane sugar solution with 3 drops of phenophthalein indicator and sufficient 1.0N NaOH to provide constant pink color) is added. The resultant solution is swirled every 5 minutes to allow the sugar to react. After 15 minutes, 0.178 N HCl (standardized with 0.9944 grams of $Na_2CO_3 \cdot H_2O$ to methyl orange end point) is used to titrate the sugar-lime solution to the phenophthalein end point. The percent available CaO is determined by multiplying the milliliters HCl required by the product of the acid normality and 28 (grams per equivalent CaO) and then dividing by the dry sample weight used and multiplying the result by 100.

ULTRACHEM
CORPORATION
1150 Civic Drive, Walnut Creek, CA 94596 / Phone: (415) 935-3115 / Cable: Ultrachem

Date: October 12, 1973

Client: Envirotech Systems, Inc.
100 Valley Drive
Brisbane, California

Attention: Mr. T. Carlson

Industrial Report: 11054

Subject: Sampling and analysis of effluent from experimental hearth furnace; from furnace and from wet scrubber. An after burner was in operation upstream of the scrubber.

Sampling site: Envirotech Systems
Brisbane, California

Sampling date and time: October 3, 1973

Sampling personnel: E. H. Gallagher, R. Brady, and R. Nigh.

Results: All are summarized on the "Tabulated Results" page following these comments or are given in "Results" section following procedures.

Remarks:
1) During the entire test, lime sludge was being fed to the furnace.
2) No volume flow measurements were made at the furnace outlet as the outlet duct flared appreciably at the location of the single sampling port available.
3) The particulate catch from the two furnace outlet samples were analyzed by emission spectrograph. The report is attached.

Sampling stations: The scrubber outlet samples were taken through the two sampling connections in the circular exhaust stack following the wet scrubber.

The furnace outlet samples were taken through the three inch sampling connections on the retangular duct about one foot above the top hearth of the furnace.

Sampling procedure: Sampling methods were as described in Regulation 2 and the Source Test Methods of the Bay Area Air Pollution Control District (BAAPCD).

The velocity of the gas was determined at the scrubber outlet by a special pitot tube and a 2 inch Dwyer inclined draft gage. The gas temperature was measured with a potentiometer and thermocouple. Traverses were made across the duct at the two test connections, 90° apart, each test.

For the particulate matter sampling at the scrubber outlet, a specially sized glass sampling nozzle was then inserted into the gas stream followed by two individual preweighed glass tubes filled with glass wool. The nozzle was positioned at one of the points of measured gas velocity during each test. The gas sample was aspirated through the specially sized sampling nozzle at the isokinetic rate established by the prior pitot monitoring tube. The gas then passed through the glass wool filled tubes and connecting tubing into three Greenburg-Smith impingers connected in series.

The first two impingers each contained 100 mls. of 1% sodium bisulfite while the third impinger was dry and contained a preweighed amount of Silica Gel. All three impingers were partially immersed in an ice bath. The sodium bisulfite was used to collect the carbonyls present in the gas, and the increase in water volume in the impingers and silica gel at the conclusion of the test was used to calculate the water vapor content of the gas.

Following the impingers,the gas was aspirated through a dry gas test meter to measure the sampled gas volume preceeded by an aspiration pump.

Similar simultaneous tests were conducted at the outlet of the wet scrubber and the outlet of the furnace.

The same sampling train was used at the furnace outlet except the glass wool filled tubes were preceeded by a stainless steel heated probe and stainless steel nozzle. The filtering thimbles were contained in a heated case and the temperature maintained at about 300°F. Additional simultaneous tests were taken for hydrocarbons, carbon dioxide, oxygen and carbon monoxide at both the inlet and the outlet and sulfur oxides at the outlet.

Samples for each of these tests were taken through an individual stainless steel sampling tube inserted directly into the gas stream.

The hydrocarbon, carbon dioxide, oxygen and carbon monoxide samples were taken through a sampling tube, a filter and moisture trap, and then directly into previously fully evacuated eight liter stainless steel gas tanks. The sample was drawn into the tank through a needle valve in an integrated manner over each test period.

The sulfur oxides samples were aspirated through one of the sampling tubes, three Greenburg-Smith impingers connected in series; a dry gas test meter to measure the sampled volume; and finally through an

aspiration pump. The first/two impingers each contained 100 mls. of 3% hydrogen peroxide to collect the sulfur oxides. All three impingers were partially immersed in an ice bath.

Two similar consecutive tests were conducted.

All sampling data is appended to this report.

Analytical procedures:

All procedures utilized are described in Regulation 2. or in approved procedures of the BAAPCD.

Particulate matter: Sections 8316 and 8317, Regulation 2. The samples were dried in an oven at 105 degrees centigrade and desiccated over drierite until they reached a constant weight.

Carbonyls: Sections 9500-9516, Regulation 2.

Sulfur oxides: Section 9110-9118, Regulation 2.

Hydrocarbons: Section 9410-9414, Regulation 2. A varian Aerograph Series 1200 gas chromatograph fitted with a flame ionization detector was used.

Oxides of nitrogen: Method N-3 of the BAAPCD.

Oxygen, carbon dioxide and carbon monoxide: Determined on an Aerograph thermal conductivity gas chromatograph.

Submitted by:

Eugene H. Gallagher
Chief Chemist

R. Nigh
Analytical Chemist

Industrial Report#: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client: Envirotech Systems, Inc.

Process tested: Multi Hearth Furnace

Test No. --TABULATED RESULTS-- Date Tested: October 3, 1973

TEST	Scrubber Outlet A	Scrubber Outlet B	Furnace Outlet A	Furnace Outlet B	Allowable
Velocity, Ft/sec (Avg)	51.2	53.8	-	-	
Duct temp; Pitot trav/Part. sample; °F	140/145	145/145	-/1310	-/1360	
Volume Flow, CFM	950	1000	-	-	
Volume Flow, SDCFM	670	710	-	-	
% H_2O	17.7	15.5	26.7	23.8	
% O_2 (Dry Basis)	15.8	16.6	9.8	8.6	
% CO_2 (Dry Basis)	4.1	3.2	8.2	8.4	
Total Sulfur Oxides, ppm (Dry Basis)	0.3	0.7	-	-	
Total Oxides of Nitrogen, ppm (Dry Basis)	19	15	-	-	
Sampled Volume, SDCF Part/ SOx	340/28.7	40.2/18.0	25.8	24.6	
Wt. of Sample, Grams	0.080	0.070	10.693	5.858	
Grain Loading, grains/SDCF	0.036	0.027	6.40	3.67	
Lb/hr of Particulate Emissions	0.21	0.16			
Ringelmann Reading-Maximum	-	-			
Time of Sampling	60	60	60	55	
Duration of test-Minutes	1310-1410	1500-1600	1310-1410	1525-1620	
Total Carbonyls, ppm	2.0	1.3	8.6	12.4	
Hydrocarbons, C_2-C_6, ppm	1.2	0.7	7.1	7.0	

Industrial Report #: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client Envirotech Systems, Inc.

Test No. A Date Tested October 3, 1973

Scrubber Outlet GAS FLOW RATE DATA

Pitot Tube Traverse

TIME	POINT	h " H_2O	T. °F.	VEL. FT /SEC	TIME	POINT	h " H_2O	T. °F.	VEL. FT /SEC
1230	1 south	.60	140	55.0					
	2	.65	140	57.3					
	3	.75	140	61.5					
	4	.75	140	61.5					
	1 east	.85	140	65.5					
	2	.75	140	61.5					
	3	.60	140	55.0					
	4	.55	140	52.7					

Avg. Gas Velocity 58.8 Ft/Sec

Pitot Tube Correction Factor 0.85

Gas Density Correction Factor 1.025

Corrected Gas Velocity:

58.8 x .85 x 1.025 = 51.2 Ft/Sec

Duct Area 0.31 Sq. Ft. Avg. Gas Temp. 140 °F

Gas Flow Rate = 51.2 Ft/Sec x .31 Sq.Ft. x 60 = 950 CFM

Gas Flow Rate 950 CFM $\times \frac{520}{460+140} \times \frac{30.15}{29.92} \times (1.00 - \frac{17.7\ \%}{100}\ H_2O)$ = 670 SDCFM

Industrial Report #: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client Envirotech Systems, Inc.

Test No. A Pilot Date Tested October 3, 1973

Process Tested Incinerator Scrubber Outlet

DATA

Sample Point 2, 3, South Sample Nozzle Diam. 6 mm i.d.

Duct Diam. 7.5 in. Barometric Pres. 30.15 in.Hg

Duct Pressure Atmosphere Pressure in.Hg Condensate 159 ml.

Avg. Gas Meter Vacuum +.7 in.Hg Avg. Dry Bubbler Temp. - °F

Avg. Gas Meter Temp. 82 °F Vol. of Gas Sampled 34.39 CF

Wgt.Collected 0.080 Gms. Sampling Time 60 Min.

CALCULATIONS

Per cent Water Vapor:

V_w = 0.00267 x 159 x 460 + 60 = 7.3 CF

V_v = _____ x _____ 29.9 C.F. =

% H_2O_v = $\frac{7.3}{7.3 + 34.0}$ x 100 = 17.7%

Corrected Meter Volume:

V_o = 34.39 x $\frac{30.15 + .7}{29.92}$ x $\frac{520}{460 + 82}$ = 34.0 SDCF

Dust Concentration:

G_o = $\frac{0.080 \text{ Gms} \times 15.43}{34.0 \text{ SDCF}}$ = 0.036 Grs/SDCF

Calculated Loss:

0.036 Grs/SDCF x 670 SDCFM x 60 = 0.21 Lbs/Hr

7000

Industrial Report #: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client Envirotech Systems, Inc.

Test No. B - Date Tested October 3, 1973

Scrubber outlet

GAS FLOW RATE DATA

Pitot Tube Traverse

TIME	POINT	h " H_2O	T. °F.	VEL. FT /SEC	TIME	POINT	h " H_2O	T. °F.	VEL. FT /SEC
1445	1 south	.55	145	52.9					
	2	.85	145	65.7					
	3	.90	145	67.6					
	4	.85	145	65.7					
	1 east	.85	145	65.7					
	2	.75	145	61.7					
	3	.70	145	59.6					
	4	.60	145	55.2					

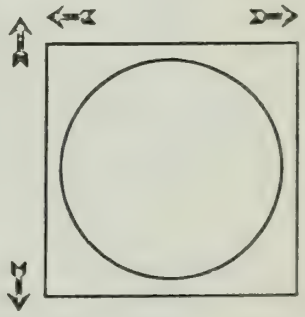
Avg. Gas Velocity 61.8 Ft/Sec

Pitot Tube Correction Factor 0.85

Gas Density Correction Factor 1.025

Corrected Gas Velocity:

61.8 x .85 x 1.025 = 53.8 Ft/Sec



Duct Area 0.31 Sq. Ft. Avg. Gas Temp. 145 °F

Gas Flow Rate = 53.8 Ft/Sec x 0.31 Sq.Ft. x 60 = 1000 CFM

Gas Flow Rate 1000 CFM $\times \frac{520}{460+145} \times \frac{30.15}{29.92} \times (1.00 - \frac{15.5\ \%}{100}\ H_2O)$ = 710 SDCFM

INdustrial Report #: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client Envirotech Systems, Inc.

Test No. B Date Tested October 3, 1973

Process Tested Pilot Incinerator
Scrubber Outlet

DATA

Sample Point 2, 3, south — Sample Nozzle Diam. 6 mm i.d.

Duct Diam. 7.5 in. — Barometric Pres. 30.15 in.Hg

Duct Pressure Atmosphere Pressure in.Hg — Condensate 133 ml.

Avg. Gas Meter ~~Xxxxxx~~ 0.4 in.Hg — Avg. Dry Bubbler Temp. - °F

Avg. Gas Meter Temp. 88 °F — Vol. of Gas Sampled 41.52 CF

Wgt.Collected 0.070 Gms. — Sampling Time 60 Min.

CALCULATIONS

Per cent Water Vapor:

$$V_w = 0.00267 \times 133 \times \frac{460 + 60}{29.9} = 6.2 \text{ CF}$$

$$V_v = \_\_\_\_ \times \_\_\_\_ \text{ C.F.} =$$

$$\% H_2O_v = \frac{6.2 + \_\_\_\_}{6.2 + 40.2} \times 100 = 15.5\%$$

Corrected Meter Volume:

$$V_o = 41.52 \times \frac{30.15 + .4}{29.92} \times \frac{520}{460 + 88} = 40.2 \text{ SDCF}$$

Dust Concentration:

$$G_o = \frac{0.070 \text{ Gms} \times 15.43}{40.2 \text{ SDCF}} = 0.027 \text{ Grs/SDCF}$$

Calculated Loss:

0.027 Grs/SDCF x 710 SDCFM x 60 = 0.16 Lbs/Hr

7000

Industrial Report #: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client Envirotech Systems, Inc.

Test No. A Date Tested October 3,1973

Process Tested Furnace Outlet

DATA

Sample Point Center | Sample Nozzle Diam. 1/2" i.d.

Duct Diam. 6" x 7 (flared) in. | Barometric Pres. 30.15 in.Hg

Duct Pressure Atmosphere in.Hg | Condensate 205 ml.

Avg. Gas Meter Pressure 0.1 in.Hg | Avg. Dry Bubbler Temp. - °F

Avg. Gas Meter Temp. 92 °F | Vol. of Gas Sampled 27.02 CF

Wgt.Collected 10.693 Gms. | Sampling Time 60 Min.

CALCULATIONS

Per cent Water Vapor:

$V_w = 0.00267 \times 205 \times \frac{460 + 60}{29.92} = 9.4$ CF

$V_v =$ _____ x _____ C.F. =

$\% H_2O_v = \frac{9.4}{9.4 + 25.8} \times 100 = 26.7\ \%$

Corrected Meter Volume:

$V_o = 27.02 \times \frac{30.15 + .1}{29.92} \times \frac{520}{460 + 92} = 25.8$ SDCF

Dust Concentration:

$G_o = \frac{10.693 \text{ Gms} \times 15.43}{25.8 \text{ SDCF}} = 6.40$ Grs/SDCF

Calculated Loss:

_____ Grs/SDCF x _____ SDCFM x 60 = _____ Lbs/Hr

7000

Industrial Report #: 11054 ULTRACHEM CORPORATION Date: October 12, 1973

AIR POLLUTION ANALYSIS

Client Envirotech Systems, Inc.

Test No. B Date Tested October 3, 1973

Process Tested Furnace Outlet

DATA

Sample Point	Center	Sample Nozzle Diam.	3/8" i.d.
Duct Diam.	6" x ? (Flared) in.	Barometric Pres.	30.15 in.Hg
Duct Pressure	Atmosphere Pressure in.Hg	Condensate	167 ml.
Avg. Gas Meter ~~Vacuum~~	0.3 in.Hg	Avg. Dry Bubbler Temp.	- °F
Avg. Gas Meter Temp.	95 °F	Vol. of Gas Sampled	25.81 CF
Wgt.Collected	5.858 Gms.	Sampling Time	55 Min.

CALCULATIONS

Per cent Water Vapor:

$V_w = 0.00267 \times \frac{167}{} \times \frac{460 + \frac{60}{29.92}}{} = 7.7$ CF

$V_v = \frac{}{} \times \frac{}{}$ C.F. =

$\% H_2O_v = \frac{7.7}{7.7 + 24.6} \times 100 = 23.8\%$

Corrected Meter Volume:

$V_o = \frac{25.81}{} \times \frac{30.15 + .3}{29.92} \times \frac{520}{460 + 95} = \frac{24.6}{}$ SDCF

Dust Concentration:

$G_o = \frac{5.858 \text{ Gms} \times 15.43}{24.6 \text{ SDCF}} = 3.67$ Grs/SDCF

Calculated Loss:

$\frac{\text{Grs/SDCF} \times \text{SDCFM} \times 60}{7000} = \frac{}{}$ Lbs/Hr

American Spectrographic Laboratories
Analysis • Research • Consultation
657 BRANNAN STREET • SAN FRANCISCO, CALIF. 94107
TELEPHONE: (415) 863-0190

October 12, 1973

ASL #0605

Ultrachem Corp.
1150 Civic Dr.
Walnut Creek, CA

Attn.: Ms. Marilyn Hardy

RE: Semi-quantitative spectrographic analyses on youritwo samples submitted on your P. O. #73/10/11/04.

The following are reported as oxides of the elements indicated.

	UC #11007, Test "A"	UC #11007, Test "B"
Ca	15. %	15. %
Mg	20.	15.
Si	3.5	2.5
Na	1.	1.5
Fe	0.8	0.7
K	—	.5
B	.25	.2
Mn	.07	.08
Ti	.015	.015
Sr	.015	.01
Ni	.015	.01
Cr	.015	.01
Cu	.005	.005
Ba	.003	.002
Pb	.005	< .005
Zn	< .1	.1
Al	.1	.08

Balance in each: Not found.

AMERICAN SPECTROGRAPHIC LABORATORIES

B. H. Hinckley

APPENDIX H-2
LABORATORY REPORT

ON

PILOT CENTRIFUGE AND MULTIPLE HEARTH FURNACE INCINERATION TEST

CONDUCTED FOR

THE CONSULTING FIRM OF CH_2M/HILL

ON

LIME SLUDGE FROM THE CH_2M/HILL PILOT PLANT

Prepared by

Envirotech Systems Incorporated

100 Valley Drive

Brisbane, California

March, 1974

ABSTRACT

The second and last lime sludge centrifugation and recalcination study was conducted for the consulting engineering firm of CH_2M/Hill in December, 1973. Both this study and that conducted in October, 1973 were conducted to determine the feasibility of two-stage centrifugation and calcination of the sludge from the CH_2M/Hill pilot plant located in San Francisco.

Operation of the P600 centrifuge in typical classification modes failed to produce any appreciable cake. This was also encountered in the first study. Acidification of the sludge to pH levels around pH 9.0 solubilized 43-45% of the magnesium and indicated an increase in cake percent solids of 30 to 130%. In view of the poor results encountered in two stage centrifuge classification, classification by acid solubilization or other methods should be investigated further.

By operating the centrifuge for maximum recoveries, a cake of 17-20% solids at 97% + recoveries and requirement of 3-6 lbs of Polymer per ton of cake dry solids was found.

Recalcination of the centrifuge cake (approximately 50% calcium carbonate, dry basis) in the multiple hearth furnace produced an ash of 35-40% calcium oxide content. The furnace operated at a calcination efficiency of 67-77% and a conversion efficiency of 52-62% which reflects about 15% bed down and dust losses. The low percent calcination is probably due to certain amounts of short circuiting encountered in the small pilot furnace. There was no significant difference in the product quality at 100 lbs/hr (4lbs/hr-ft^2) or 200 lbs/hr (8lbs/hr-ft^2).

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I. INTRODUCTION

This report summarizes the second and last of two lime sludge centrifugation and recalcination studies conducted for the consulting engineering firm of CH_2M/Hill. The purpose of the studies was the evaluation of the feasibility of sludge classification by two stage centrifugation and recalcination by multiple hearth furnace.

The lime sludge for the second study was received from the CH_2M/Hill pilot plant located at the North Point Water Pollution Control Plant in San Francisco. A flow diagram of the sludge generation, centrifugation and recalcination appears in Figure 1. (See Page 2). The settled sludge in drums was delivered to the Envirotech Laboratory at Brisbane, California where it was dewatered by a Sharples centrifuge and the centrifuge cake recalcined in the multiple hearth furnace. The centrifuge work was conducted by Sharples personnel and the furnace work by Envirotech personnel. The test ran from December 3 through December 6, 1973 and was conducted under Job Number 2013-22.

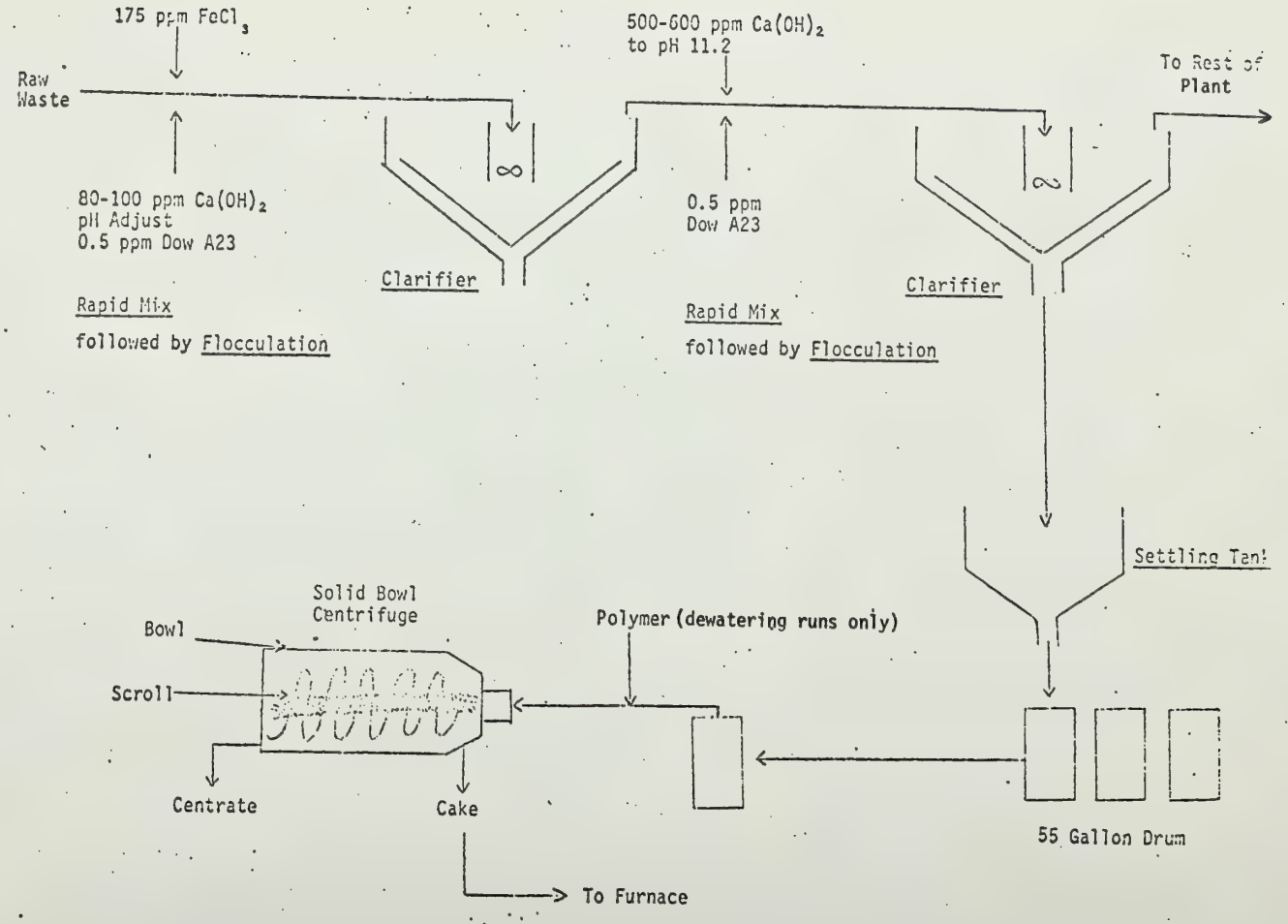


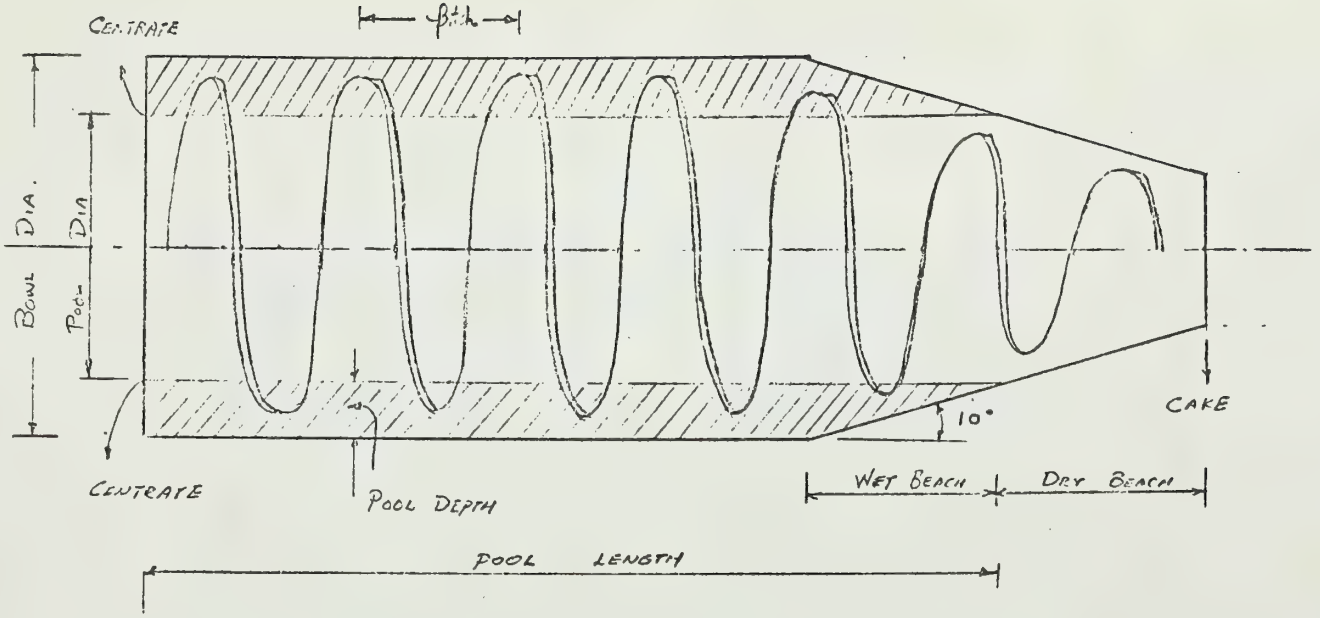
Figure 1 - Sludge Dewatering Flowsheet

DESCRIPTION OF APPARATUS

The pilot facilities for this test included a P600 6" diameter solid bowl centrifuge and a BSP 30" inside diameter 6 hearth furnace.

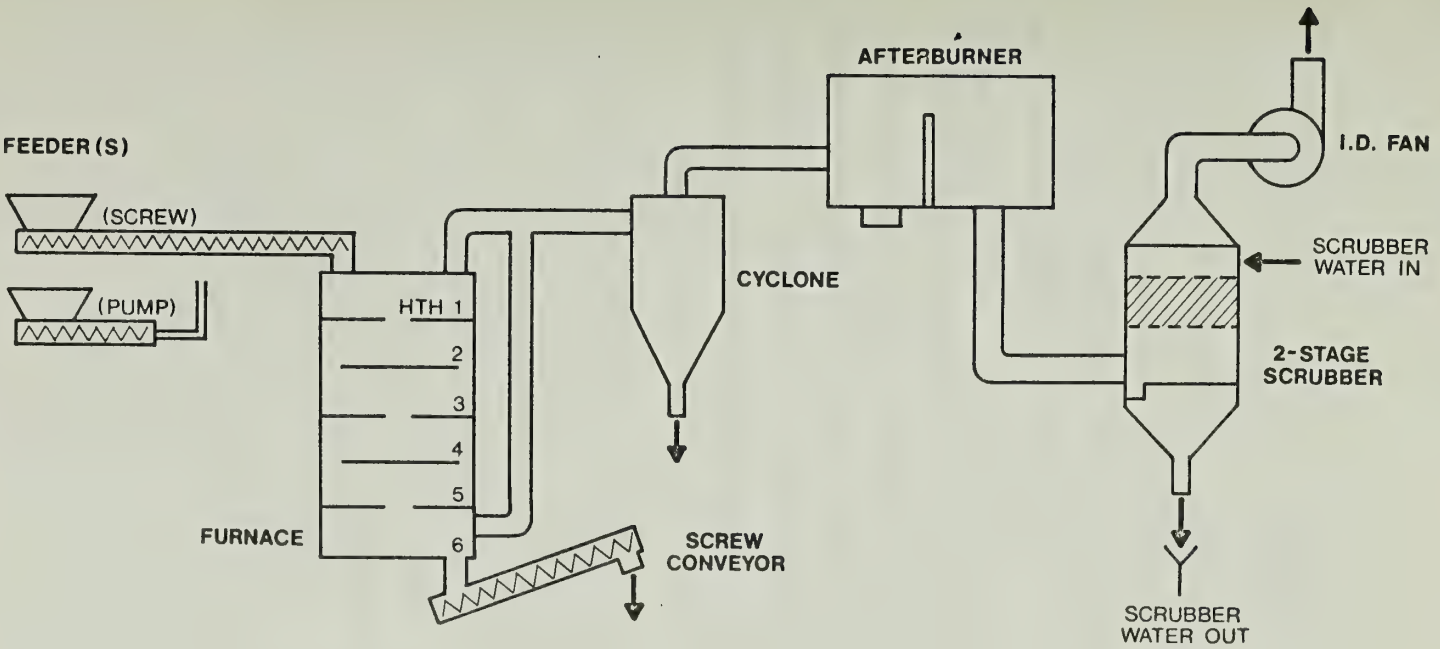
The P600 centrifuge has an adjustable bowl speed of from 0-6000 rpm capable of producing 0-3067G in the 6" bowl. The scroll differential is also adustable from 0-50 rpm. The pool depth is adjustable from a minimum setting of 1 to a maxium of 4. (See Figure 2) The recommended ranges for full-scale operation are 1800-2500G and a scroll differential of 10-25 rpm.

The 30" inside diameter 6 hearth, multiple hearth furnace has approximately 25 ft^2 of effective hearth area. The material is fed into the 1st hearth and discharged from the 6th. (An overall arrangement is depicted in Figure 3). There are two natural gas burners per hearth. The"off gas"system includes a dry cyclone for large particulates capture, an afterburner for residual combustibles ignition, a wet scrubber for fine solids capture and an induced draft fan and stack.



Centrifuge Model	Pond No.	Pond Radius	Wet Beach Length	Dry Beach Length	Pool Volume
P-600 6"Ø x 13.3"	#1	2.81 in.	1.09 in.	2.72 in.	0.161 gal.
	#2	2.69 in.	1.79 in.	2.00 in.	0.275 gal.
	#3	2.56 in.	2.52 in.	1.27 in.	0.428 gal.
	#4	2.34 in.	3.79 in.	0	1.12 gal.

FIGURE 2
SHARPLES P600 CENTRIFUGE



30" I.D. x 6 HTH PILOT FURNACE SYSTEM

Figure 3

EXPERIMENTAL PROCEDURE

Analytical work was started on December 3rd to determine if acid treating the sludge would improve the classification and/or dewatering of the sludge. Jar tests were conducted on 1 liter samples of sludge dosed with sulfuric acid to pH values of 11.0, 10.5, 9.5, 8.5 and 8.0. The samples were dosed, rapid mixed, flocculated and allowed to settle. Portions (200 ml) of the mixed sludge were centrifuged at approximately 2500 rpm in a clinical centrifuge for 2 minutes. The sludge volume and centrate were recorded. Calcium and magnesium by EDTA titration and the total suspended solids of the supernatant were determined. The results appear in Table 1 (Page 9).

On December 5th and 6th,centrifuge runs were started by Sharples personnel on the sludge as received from CH_2M/Hill. The initial settings of 50 rpm scroll differential and pond setting of 1, normally used for classification, were set up first. (No polymer was added). There was no appreciable amount of cake produced. Lower scroll differentials were tried with no success. (These same conditions were also tried in the first study without success). It was then decided to run the centrifuge for maximum recovery. Various feed rates, pond settings and polymer feed rates were used to determine the best conditions for recovery. The feed,

cake,and centrate total solids were determined to enable calculation of the recovery, pounds of cake dry solids per hour production and polymer use in pounds of polymer per ton of cake dry solids. These results appear in Table 2 (Page 10). Also attached as Appendix B (Page 23) is a letter from Sharples on both studies conducted for CH_2M/Hill.

The centrifuge cake was fed to the furnace on December 6th. The furnace was initially heated up to temperature. The burner mixtures were adjusted to provide an excess air or oxidizing condition. The exhaust gases were drafted through the cyclone, afterburner and scrubber. (The burner in the afterburner was not used). The centrifuge cake was fed into the first hearth by the adjustable screw feeder at a rate of 100 lbs/hr. Approximately two hours were spent in bedding down the furnace. Halfway through the run, the feed rate was raised to provide the full-scale loading rate of 8 lbs/hr-ft^2. There was no material collected from the cyclone.(After the test it was found that the cyclone discharge was plugged due to solids from an earlier test). The feed material and product were analyzed according to procedures in Appendix A, (Page 20). The feed sludge was analyzed for percent moisture (103°C), percent volatiles (600°C) and percent ignition loss (600°C-950°C weight loss). The devolatilized feed sludge sample and the product samples were analyzed for percent acid soluble-water insoluble calcium hardness expressed as percent calcium carbonate, water soluble calcium hard-

ness expressed as percent calcium oxide, acid soluble magnesium hardness expressed as percent magnesium oxide, and ortho and condensed phosphates according to the methods in Appendix A.

The operating conditions of the furnace, the analytical results on the feed and product, and the percent conversion efficiency based upon lbs. of calcium oxide output divided by the theoretically obtainable lbs. of calcium oxide appear in Table 3, (Page 11).

TABLE 1

Lime Sludge from CH_2M-Hill Batch 2
Acidification Jar and Centrifuge Tests

Sample #	Initial pH	Sample Volume, l.	H_2SO_4 Added Milli-equivalents/l	Dosed pH	Flocculation pH	Centrifuged Volume ml	Cake Volume ml	Centrate Hardness mg/l as $CaCO_3$ Calcium	Centrate Hardness mg/l as $CaCO_3$ Magnesium	Centrate Total Suspended Solids mg/l
A	11.28	1	0	-	-	200	68	632	32	19
B	11.34	1	2.5	10.99	10.91	200	70	672	44	12
C	11.33	1	5	10.51	10.43	200	68	732	100	8
D	11.36	1	17	9.51	10.02	200	70	768	572	17
E	11.29	1	150	8.50	9.21	200	54	1300	6660	22
F	11.32	1	225	8.04	8.91	200	30	1460	6940	25

NOTE: Unacidified sludge - 3.65% total solids, 0.26% total dissolved solids.

TABLE 2

Lime Sludge from CH_2M-Hill Batch 2
P600 Centrifuge Runs

Run #	Effluent Rate gpm	Pond Number	Polymer ml/min	Rate mg/l	% Total Solids			% Recovery	Lbs of Cake Dry Solids/hr	lbs of Polymer/Ton of Cake Dry Solids
					Feed	Cake	Centrate			
1	2.88	4	857	80	-	12.7	4.7	18.6	13.6	16.7
2	2.80	4	1136	120	-	17.2	0.3	99.7	90.4	3.3
3	1.90	4	269	30	5.2	11.3	3.3	54.9	34.5	2.1
4	1.96	4	857	130	-	13.9	0.5	97.2	67.2	3.4
5	1.96	3	986	153	5.3	18.4	1.1	87.6	50.2	5.2
6	1.89	3	1136	190	-	20.0	0.4	98.4	53.0	5.7
7	2.00	3	857	130	-	20.1	2.4	66.5	34.9	6.5
8	2.86	3	0	0	5.5	30.8	4.8	11.7	8.6	0
9	2.92	3	857	84	-	20.0	4.0	38.3	23.8	9.5
10	2.90	3	1136	115	-	18.3	3.2	49.9	38.5	7.8
11	-	3	1402	-	-	17.9	1.8	76.3	-	-

NOTE: 1) Feed was ~ 5.3% TS, 0.26% TdS

2) Bowl speed was 5000 rpm for entire test. Scroll differential was 24 rpm throughout test.

3) Polymer strength is 1 mg/ml of Percol #726 High Anonic

4) Run #6 TdS is 0.31%

5) % Recovery = $\frac{(\%\ TS\ of\ Cake - \%\ TDS)\ (\%\ TS\ Feed - \%\ TS\ Effluent)}{(\%\ TS\ of\ Feed - \%\ TDS)\ (\%\ TS\ Cake - \%\ TS\ Effluent)} \times 100$, % TDS = 0.28, % TS of Feed = 5.3%

6) Lbs. cake d.s./hr. $\simeq$ (Effluent rate - polymer rate) gpm X 60 min./hr. X 8.34 lb/gal X $\frac{(\%\ TS\ Feed - \%\ TS\ Effluent)}{(\%\ TS\ Cake - \%\ TS\ Feed)} \frac{(\%\ TS\ Cake)}{(100)}$ where feed rate = effluent rate $\frac{(\%\ TS\ cake - \%\ TS\ effluent)}{(\%\ TS\ Cake - \%\ TS\ Feed)}$

7) Lbs of polymer/ton cake dry solids =
ml/min polymer x 1 mg/ml X 60 min./hr X lb/453,000 mg X 2000 lb/T X 1/lbs cake D.S. per hour

TABLE 3

Lime Sludge from CH_2M-Hill Batch 2
Multiple Hearth Furnace Run

Time	Retention Time (min)	Feed Rate lbs/hr	Hearth Temperatures #1	#2	#3	#4	#5	#6	Total Gas cfh	Product lbs/hr	Product Analysis (1) % CaO	Acid (3) Soluble	% MgO	% P	% Conversion Efficiency(2)
10:30	60	100	1320	1840	1850	1880	1840	1850	-	-	-	-	-	-	-
11:30	60	100	680	1820	1830	1810	1850	1850	580	-	-	-	-	-	-
12:30	60	100	500	1820	1850	1890	1880	1860	530	-	-	-	-	-	-
3:59	60	100	500	1870	1900	1890	1880	1850	647	17	35	33	28	0.03	97
6:15	60	200	150	1780	1880	1880	1880	1880	740	14	-	-	-	-	
7:03	60	200	350	1770	1890	1840	1820	1850	574	19	40	27	25	0.01	-
8:00	60	200	250	1780	1880	1860	1830	1850	600	10	-	-	-	-	-
9:05	60	200	150	1660	1820	1850	1840	1880	570	16	40	34	24	-	-
10:00	60	200	150	1630	1800	1870	1840	1860	633	16	-	-	-	-	-
11:05	60	200	160	1690	1850	1880	1840	1860	674	20	35	34	23	0.01	-
12:08	60	200	200	1660	1830	1870	1840	1880	676	21	-	-	-	-	-

Feed Analysis: 79.9% Moisture, 19.7% Volatiles (D.B.),20.3% Ignition Loss,(68% $CaCO_3$, 21.2% MgO, 6.72% CaO,.095% P in devolatilized sample), 54.6% $CaCO_3$ D.B., 17.0% MgO D.B., 5.4% CaO D.B., 0.07% P D.B.

NOTES:

1) See Appendix A for analytical methods. The percent acid soluble-water insoluble calcium compounds for domestic wastewater lime treatment sludge is generally calcium carbonate.

2) % conversion efficiency = $\frac{\text{discharge rate} \times \% \text{ CaO}}{\text{feed rate} \times (.201 \text{ lb solids/lb feed}) \times 51.6\% \ CaCO_3 \times 0.56 \text{ lb CaO/lb } CaCO_3} \times 100$

3) Acid soluble-water insoluble calcium as % $CaCO_3$.

DISCUSSION OF RESULTS

Jar Tests:

The jar tests were undertaken to determine what benefit, if any, in the sludge dewatering and classification would result from acidification at various pH levels. The results show that the sludge volume produced by centrifuging the acidified sludge remained about the same down to pH 9-10. Below this there was a substantial drop in the sludge volume with an abrupt rise in the calcium and magnesium hardness of the centrate. These results indicate that appreciable amounts of calcium and especially magnesium were going into solution.

The amount of acid required and the removal of calcium and magnesium hardness from the sludge can be estimated from the data in Tables 1 and 3. The amount of acid to reach a pH of 9.21 after flocculation was 150 millequivalents per liter or 7,350 milligrams per liter. In terms of pounds per ton of dry solids,this is about 400 lbs/T. The amount of magnesium hardness removed, as magnesium hydroxide per liter of sludge was 3,870 milligrams per liter. The amount of calcium hardness removed as calcium hydroxide per liter of sludge,was 495 milligrams per liter. The unacidified sludge composition can be estimated from the furnace feed dry solids composition found in table 3. The percent magnesium in dry solids,expressed as magnesium hydroxide,is 24.6% The percent calcium, as calcium

oxide, is 7.1%. In terms of milligrams per liter, the sludge composition is approximately 8,980 mg/l of magnesium hydroxide and 2,590 mg/l of hydroxide. The removal of magnesium hydroxide and calcium hydroxide by acidification to flocculation pH 9.2 is therefore about 43% and 19% respectively. A lower flocculation pH of 8.9 yielded 45% and 24% respectively at acid requirement of about 600 lbs/T dry solids.

The results of the jar test indicate that classification by acid or other means to remove magnesium will result in improvement in dewatering of the sludge. Experimentally the removal of about 43% of the magnesium resulted in a reduction in sludge volume of approximately .77 (54/70).

The centrifuge cake solids may be increased 30% or about 1.3 times (1/.77). A lower flocculation pH of 8.91 indicated a sludge volume decrease of .43 (30/70). The centrifuge cake solids may be increased 132% or 2.32 times (1/.43). Due to the acid requirements,this method, although promising in a full scale application, was not attempted for the sludge centrifuge work in this study

Centrifuge Runs:

The centrifuge was set up and operated by Sharples personnel. Attached as Appendix B is a letter from Sharples on the operation and conclusions for both this study and the earlier one.

Attempts were made to classify the sludge at a pond setting of 1 and scroll differentials from 50 down to 25. No significant amounts of cake were produced, which were also the results of the first study. Attempts were then made to maximize the cake recoveries. Maximum recoveries were found at effluent rates of 1.89 and 2.80 gpm, at pond settings of 3 and 4, and polymer doses of 120 and 190 mg/l. The maximum cake percent solids produced with polymer was approximately 20%. Without polymer, the results were 30% cake solids at a recovery of only 12%.

For some reason,both this sludge and that of the first study do not lend themselves to two-stage centrifuge classification. Pilot centrifuge work at typical classification settings for a long dry beach (pond setting of 1) and high differential scroll speeds (25-50 rpm) were not successful. (See Appendix B.)

The previous study indicated some classification (75% calcium carbonate in cake) was possible at low recoveries (3-8% total, 4-11% as calcium carbonate). (The runs were conducted at a pond

setting of 1, differential scroll speed of 9.7 rpm, effluent rate of 5.19 gpm and bowl speed of 5000 rpm). It appears from the results of the previous study and this study that either the sludge is reslurrying at the classification conditions to produce the low recoveries or there is some characteristic of the sludge that restricts the separation of calcium carbonate from magnesium hydroxide.

The acidification jar test studies did produce considerable classification of the sludge. A subsequent increase in the percent solids in the cake was also indicated. It is perhaps this area that should be investigated if classification is necessary. Possible systems involving acid addition or recarbonation should be evaluated.

Furnace Operation:

The furnace operation results appear in Table 3. An evaluation of the furnace efficiency is difficult because of some inconsistencies in the data. The determination of the maximum percent calcium oxide, theoretically able to be produced by complete calcination of the feed, is required for the determination of the furnace recalcination efficiency. This was attempted in three ways: from the ignition loss of the feed; from the acid soluble-water insoluble calcium hardness of the feed; and from the acid soluble-water insoluble calcium hardness on the product. The following table summarizes the results of each approach.

By Ignition Loss:

Basis: 20.3% ignition loss equals carbon dioxide evolved by calcination of calcium carbonate to calcium oxide from 600°C to 950°C overnight. 5.4% calcium oxide infeed. Complete calcination.

Calculations: 20.3% ignition loss ÷ 0.44 lb of carbon dioxide evolved per lb of calcium carbonate equals 46.1% calcium carbonate in feed dry solids.

$$\frac{(5.4\%\ CaO + 46.1\%\ CaCO_3 \times 0.56\ lb\ CaO/lb\ CaCO_3)}{(100\%\ dry\ feed - 19.7\%\ volatiles - 20.3\%\ ignition\ loss)} \times 100\%$$

= 52% calcium oxide

Result: 52% calcium oxide (maximum theoretical in ash)

By Feed Analysis:

Basis: 68% calcium carbonate, 6.7% calcium oxide in devolatilized feed. All acid soluble-water insoluble calcium hardness is due to calcium carbonate.

Calculation:

$$\frac{(6.7\%\ CaO + 68\%\ CaCO_3 \times 0.56\ lb\ CaO/lb\ CaCO_3)}{(100\%\ devolatilized\ feed - 68\%\ CaCO_3 \times 0.44\ lb\ ignition\ loss/lb\ CaCO_3)} \times 100$$

= 64% calcium oxide

Result: 64% calcium oxide (maximum theoretical in ash)

By Product Analysis:

Basis: 37.5% average calcium oxide, 32% average calcium carbonate in product. All acid soluble-water insoluble calcium hardness due to calcium carbonate.

Calculation:

$$\frac{(37.5\%\ CaO + 32\%\ CaCO_3 \times 0.56\ lb\ CaO/lb\ CaCO_3)}{(100\%\ ash - 32\%\ CaCO_3 \times 0.44\ lb\ ignition\ loss/lb\ CaCO_3)} \times 100$$

= 64% calcium oxide

Result: 64% calcium oxide (maximum theoretical in ash)

The above results indicate that either all of the percent acid soluble-water insoluble calcium hardness is not calcium carbonate or that the overnight muffle furnace test did not completely calcine all of the calcium carbonate. An experiment with reagent calcium carbonate calcined in a muffle furnace in the same manner resulted in a 44% ignition loss, as predicted for complete calcination. The conclusion is that the 52% value represents the maximum calcium oxide obtainable

for a furnace calcination efficiency of approximately 77%. The percent conversion efficiencies reflected the furnace losses and indicated the furnace ran at an average of 67%. (The 97% value for the 100 lb/hr run reflected operation at low loading rates where the bed was much smaller and perhaps the dust loss was much less). The difference between this and the calcination efficiency, or 15%, was accounted for in terms of dust loss and bed down loss.

APPENDIX A

ANALYTICAL PROCEDURES

APPENDIX

% Moisture

Approximately 25 grams of material is weighed into a tared container to the nearest 0.001 gram. The sample is placed into an oven at 103° C. overnight or until there is no further weight loss. The sample is then withdrawn, allowed to air cool, placed in a dessicator, and weighed. The percent moisture is determined by dividing the weight loss of the sample by the sample weight and then multiplying the result by 100.

% Volatiles

Approximately 1.000 grams of the dry sample is put into a tared, covered crucible which is then placed into a muffle furnace at 600° C. and after an hour is withdrawn and weighed. The percent volatiles is determined by dividing weight loss by the sample weight and multiplying the results by 100.

% Ignition Loss

Approximately 1.000 grams of the devolatilized sample is put into a tared crucible and placed into a muffle furnace at 950° C overnight. In the morning, the sample is withdrawn and weighed. The ignition loss is determined by dividing the weight loss by the sample weight and then multiplying by 100.

% CaO

200 milligrams of the dry material[1] is weighed into a volumetric 1 l flask. Distilled water is added to the mark, a stirring bar added and the sample mixed for 15 minutes. A 50 ml sample is then withdrawn, 2 ml of 1N NaOH added and then two packets of Hach indicator Calver II. The sample is titrated with EDTA titrant (1 ml = 1 mg. Ca as $CaCO_3$) until a sky blue color persists. The milligrams CaO as $CaCO_3$ equals the milliliters EDTA times 20. The percent CaO is determined by multiplying the milligrams CaO as $CaCO_3$ by .56 and dividing by the milligrams dry sample.

% $CaCO_3$

200 milligrams of the dry material[1] is weighed into a 1 l volumetric flask. 5 ml of 1:1 HCl is added and the flask swirled to dissolve the calcium carbonate mixture. 100 ml of distilled water is added and 5 N NaOH is added to neutralize the residual HCl. Distilled water is added to the mark. The resultant solution is then analyzed for calcium as $CaCO_3$ in the same manner as for % CaO above. The percent $CaCO_3$ is determined by dividing the milligrams calcium as $CaCO_3$ by the dry sample weight and multiplying the resultant by 100%. From this percent total calcium as $CaCO_3$, the percent CaO divided by 0.56 is subtracted to yield the percent $CaCO_3$.

[1]Devolatilized or furnace product.

by calcination of the sludge. This would indicate that the feed sludge was approximately 50% calcium carbonate, dry solids basis and that acid soluble-water insoluble calcium hardness included some non-calcium carbonate material.

Based upon these results,the maximum calcined product would have a composition of 52% calcium oxide, 21.2% magnesium oxide and 26.8% inerts containing calcium, phosphate and other materials. The efficiency of recalcination for a product of 35% calcium oxide would be 67.3% and for a product of 40% calcium oxide, 76.9%.

This low calcination efficiency is within the range encountered for the small pilot furnace. Due to the small hearth area relative to the drop hole size and the rabble arm spacing,a certain amount of short-circuiting encountered which results in the low calcination efficiency of the furnace.

The furnace operation indicated that the average discharge was about 16-17 lbs/hr., the natural gas consumption 580-640 ft^3-hr. at feed rates of 100 and 200 lbs/hr., respectively. There was no significant difference in the product quality at 100 or 200 lbs/hr. This indicated that a rate of 200 lbs/hr or 8 lbs/hr-ft^2 was adequate to calcine the centrifuge cake to 40% calcium oxide

% Available CaO

Sufficient dry sample is ground and passed through 100 mesh screen to yield approximately 0.50 grams is placed into a flask and 50 milliliters of boiling water added. The solution is boiled for 1 minute, cooled and 50 ml of sugar solution (33% by weight cane sugar solution with 3 drops of phenophthalein indicator and sufficient 1.0N NaOH to provide constant pink color) is added. The resultant solution is swirled every 5 minutes to allow the sugar to react. After 15 minutes, 0.178 N HCl (standardized with 0.9944 grams of Na_2CO_3-H_2O to methyl orange end point) is used to titrate the sugar-lime solution to the phenophthalein end point. The percent available CaO is determined by multiplying the milliliters HCl required by the product of the acid normality and 23(grams per equivalent CaO) and then dividing by the dry sample weight used and then dividing by the dry sample weight used and multiplying the result by 100.

% MgO

A sample of the dry material[1] is treated in the same manner as for % $CaCO_3$. A total and calcium hardness determined on the solution. The difference of the total and calcium hardness is multiplied by 0.40 and divided by 200. Multiplication of the answer by 100 yields the percent magnesium as magnesium oxide.

APPENDIX B

PENNWALT CORPORATION

SHARPLES
CENTRIFUGES
454 CARLTON COURT, SOUTH SAN FRANCISCO, CALIFORNIA 94080 · (415) 589-8264

March 18, 1974

Mr. Tom Carleson
Envirotech Systems, Inc.
Post Office Box 8918
San Francisco, CA 94128

Subject: Sharples P-600 Super-D-Canter Test Program
Lime Sludge Dewatering at ESI for
City of San Francisco/CH2M-Hill

Dear Mr. Carleson:

On two separate occasions (10/1/73 through 10/5/73 and 12/3/73 through 12/6/73), lime sludge dewatering tests were conducted using the Sharples P-600 Super-D-Canter solid bowl scroll centrifuge operating on limed primary clarifier overflow generated at pilot plant facilities, City of San Francisco waste treatment plant by CH2M-Hill. The purpose of these tests was to investigate single stage centrifuge dewatering as well as two stage classification-clarification centrifuge capability, and to generate sufficient volumes of sludge to permit ESI to operate incinerator test program.

During both centrifuge test programs mentioned above, attempts were made to operate the P-600 Super-D-Canter in the conventional classification mode; i.e., 5000 RPM (2100 x G) #1 pond pool depth setting, 50 RPM differential speed with torque arm on gearbox. Sludge feed rate to the centrifuge was varied from 3 GPM through 8 GPM. No classification occurred under these conditions. Since no cake was discharged from the centrifuge and no samples taken under these operating conditions, this portion of the test program was not formally reported to ESI.

Over the past several years Sharples has conducted a number of pilot plant test programs on a variety of lime sludges, ranging from limed primary, limed primary clarifier overflow, limed secondary clarifier overflow, as well as water softening sludges from potable water treatment plants. Depending upon the size of the plant involved and the quantities of sludges generated, most of these test programs included data generated from two stage classification-clarification sludge dewatering as well as single

stage sludge dewatering. To the writer's knowledge, we have never before encountered a lime sludge of any type where no classification occurred under the operating conditions mentioned above. In fact, lime treated primary clarifier overflow sludge generated at another California waste treatment plant classified and clarified as expected using the identical P-600 Super-D-Canter tested at ESI. The pH for this lime sludge ranged from perhaps 10.3 to 11.5. Operating the centrifuge under the classification mode resulted in an average 40% recovery of total suspended solids with cake discharged at 50-60% w/w total solids.

During the two test programs conducted at ESI, the P-600 was operated at 3 pond setting and 4 pond setting, utilizing a back-drive arrangement to control scroll speed differential, with and without internal addition of polyelectrolytes. Recoveries of suspended solids under all operating conditions were low without the use of polyelectrolytes. During the test programs, poly-electrolyte addition was varied through a range of perhaps 1 to 5 lbs. per ton dry basis solids in order to generate cake discharges at various recovery levels, the purpose of which was to provide centrifuge cake for chemical analysis to determine whether or not a lime rich classified cake could indeed be generated under any operating condition.

The only apparent difference between the City of San Francisco lime sludge and that tested at other pilot plant operations appears to be a relatively high magnesium content in the San Francisco lime sludge. Perhaps some consideration should be given to centrifuge classification of limed sludges at a lower pH than that tested previously. At a pH below 10.5 magnesium hydroxide is more soluble than at a pH of 11.5. The more soluble magnesium hydroxide at lower pH's has a less adverse effect on centrifuge classification of limed sludge. In any event, centrifuge classification of sludge as tested at ESI under the traditional centrifuge classification operating parameters cannot be considered successful.

I hope the above information meets with your approval. If I may be of further service, please do not hesitate to call.

Very truly yours

SHARPLES STOKES DIVISION
PENNWALT CORPORATION

Charles G. Lloyd
Sales Engineer

CGL/ck

APPENDIX H-3

CH_2M/Hill
360 Pine Street
San Francisco, California 94104

LABORATORY STUDY ON THE EFFECTS OF CHEMICAL COAGULANTS ON ANAEROBIC DIGESTION OF RICHMOND-SUNSET SLUDGE

by

James M. Gossett and
Perry L. McCarty, Consultant
823 Sonoma Terrace
Stanford, California 94305

April 1974

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I. INTRODUCTION

The use of chemical coagulants to enhance a suspended solids removal from municipal wastewater has been proposed for the City of San Francisco Richmond-Sunset facility. While the ability of precipitants such as alum or ferric chloride to increase suspended solids removal efficiency is without question, some concern has been raised with regard to possibly deleterious effects on the subsequent anaerobic digestion of municipal sludges which might contain high levels of aluminum or iron.

The use of alum for precipitation was evaluated at plant scale by CH2M HILL for the City of San Francisco. When a dosage of about 250 ppm of alum was added to the wastewater during a three month test, the digestion gas production decreased by greater than 50 percent. This raises a serious question about the practicality of alum usage. However, given the difficulties of accurately measuring plant-scale digester performance at Richmond-Sunset and the presence of some anomalous flow conditions during the study, it was decided to perform laboratory bench-scale digestion studies to further assess the situation. The following study was conducted by James M. Gossett and Perry L. McCarthy in response to a purchase order from CH2M HILL dated January 14, 1974.

II. EXPERIMENTAL PROCEDURES

A. DIGESTER OPERATION. Seven 750 ml laboratory digesters were fed sludge prepared by CH2M HILL personnel by dosing a batch of wastewater from the Richmond-Sunset plant with various levels of either alum, ferric chloride, or Magnifloc 509-C (an organic coagulant aide). An eight digester serving as a control was fed ludge obtained by settling wastewater without addition of coagulants.

The digesters were all initially started by seeding with 750 ml of digested sludge from the primary digester at the Richmond-Sunset facility

then fed on a semi-continuous basis with a detention time of 15 days. Each day the digesters were shaken, 50 ml was withdrawn, 50 ml of feed sludge was added, and the digesters were again shaken and left at 35 deg C until the next day when the procedure was repeated. Gas production was recorded daily by measuring the displacement of an acid-salt solution in each of eight 1500 ml calibrated tubes. Effluent pH, alkalinity, volatile acids, total solids, volatile solids, and chemical oxygen demand were measured regularly, as was gas composition (with a Fisher Gas Partitioner). Values for COD, total solids (TS), and volatile solids (VS) were obtained for four replicate samples of each feed sludge initially, with another series of replicates run at the end of the period of utilizing the particular feed batch, to demonstrate that no significant changes in feed sludge composition had occurred during refrigerated storage.

The systems were operated periodically under both positive and negative pressures, to demonstrate that, since measured gas productions were essentially the same in both cases, no leaks were present in the systems.

B. Sludge Derivation. Sludges were prepared on two occasions for feeding the laboratory digesters. The first batch (Batch I) lasted through day 37, and the second batch (Batch II) was used from day 38 through day 61.

Initially, coagulant doses were chosen to bracket the optimal dose as indicated from jar tests. For example, 200 ppm alum was judged optimal, hence 150 ppm, 200 ppm, and 250 ppm alum were the doses used to prepare three separate samples of sludge.

Since ferric chloride was also a possible candidate for future use as a coagulant at Richmond-Sunset, a series of ferric chloride doses was also evaluated for digestibility: 100 ppm, 150 ppm, and 200 ppm (as before, these doses were based upon the finding that 150 ppm was optimal).

Control sludge was obtained by settling the same wastewater without coagulant addition.

The initial sludges were each prepared by adding coagulant and caustic soda to 30 gallons of wastewater, followed by mechanical mixing and subsequent settling to about 1% solids, followed by centrifugation to about 4% solids. The resulting sludges were mixed with a blender, screened through 1/4-inch mesh to remove large particles which would interfere with feeding in laboratory units, and adjusted to 2.5% volatile solids by addition of tap water.

One unscreened control was run (with great difficulty because of clogging) for 13 days to demonstrate that screening had little, if any, effect on performance. At the end of 13 days, this reactor's feed was changed to a sludge derived from dosing a new wastewater sample with Magnifloc 509-C at 300 ppm, to assess its effect on digestion. It should be noted, however, that the wastewater used for preparation of this Magnifloc sludge was not the same as was used earlier for the other sludges of Batch I.

When the second batch of sludges was prepared, it was decided that the 150 ppm alum dose would be changed to 325 ppm alum, a level of dosing which might actually be reached on some occasions during plant operation. This, and the fact that the Magnifloc sludge was not prepared from the same wastewater as the others, was the only change in preparation between Batch I and Batch II sludges. Again the sludges were blended, screened, and adjusted to 2.5% VS.

III. RESULTS

Detailed data can be found in Appendix A. The gas production data are summarized as five-day running averages of both ml of gas/day and ml CH_4/g COD added in Figures 1 through 6.

It can be observed from Figures 1 and 3 that, almost from the beginning, differences in gas production could be noted between coagulant dosed and control sludges. This is true even when performance is corrected for

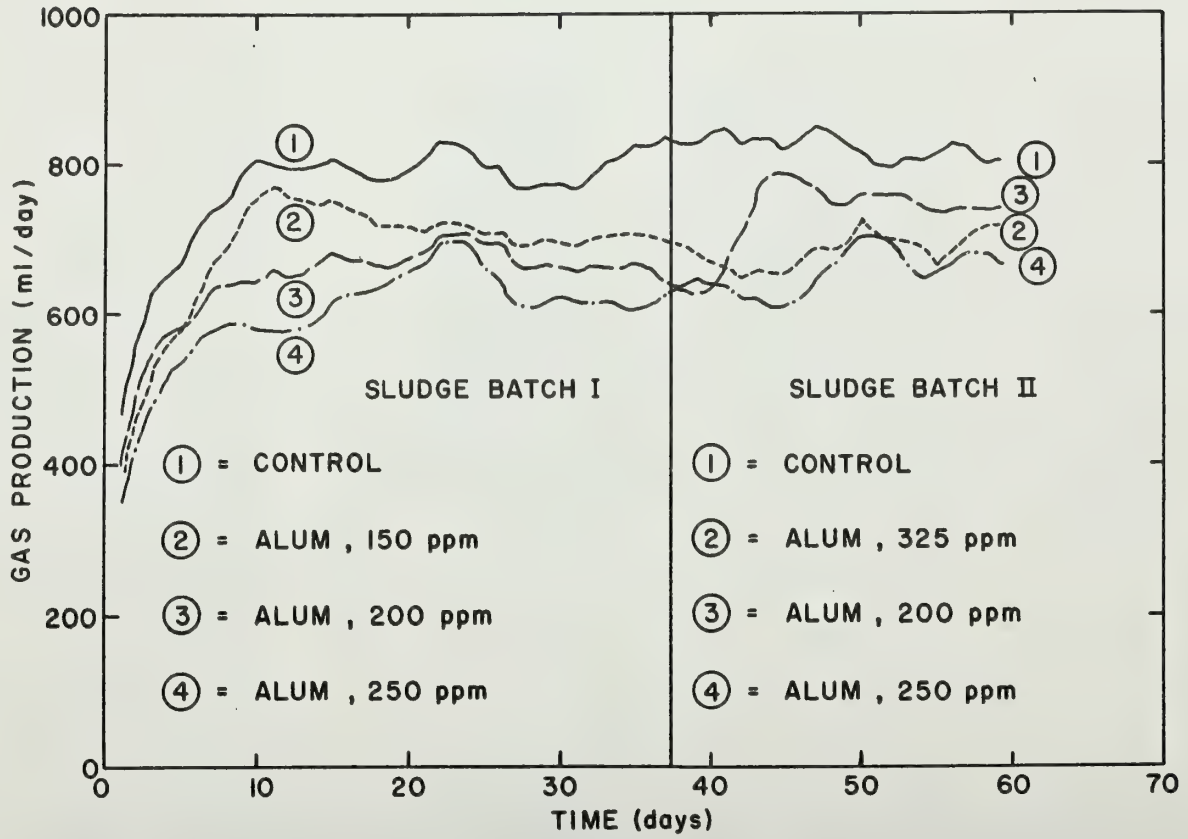

Figure 1. Daily Gas Production from Alum Treated Sludge Digestion (5-Day Running Averages).

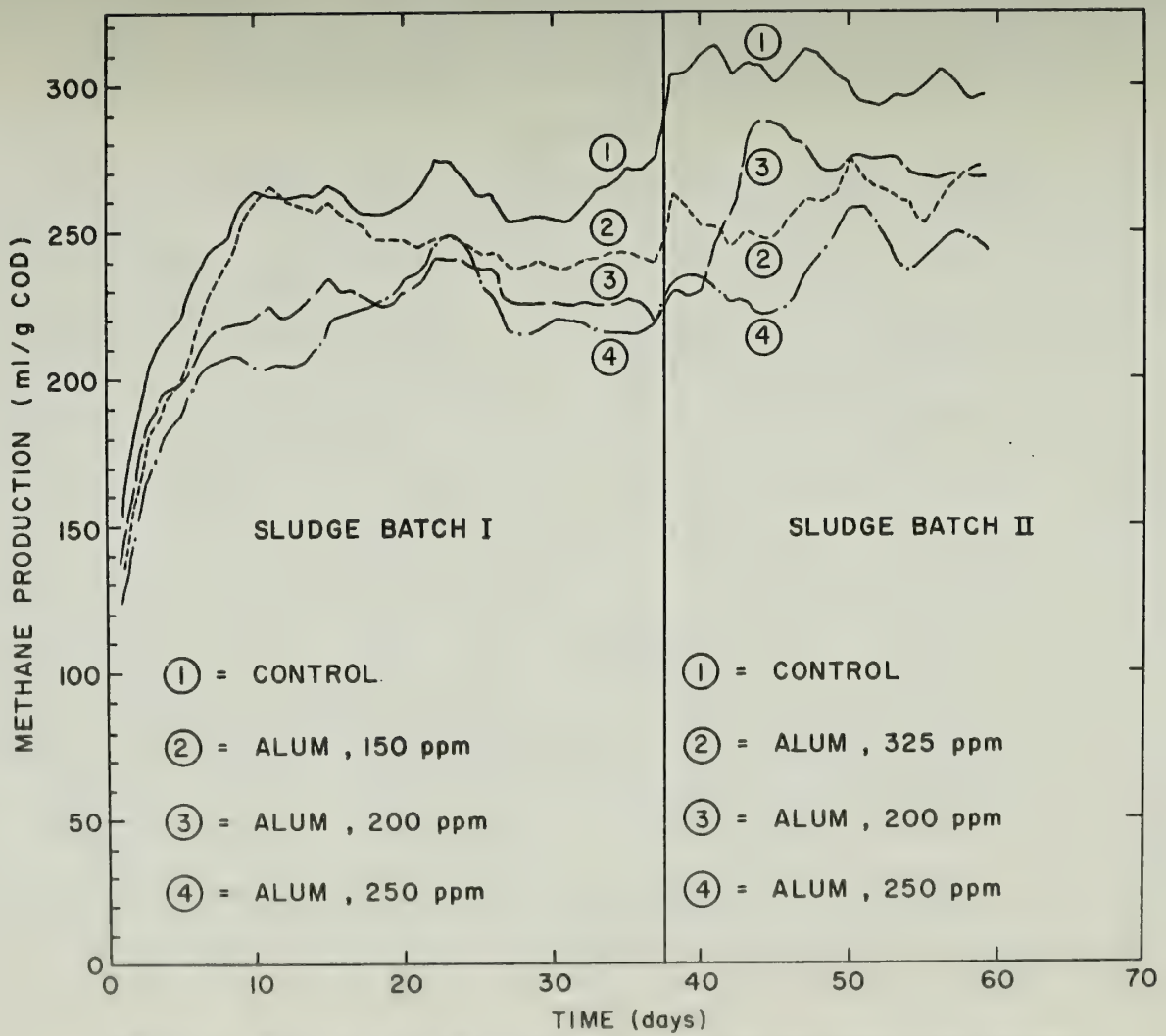

Figure 2. Daily Methane Production per Gram COD Fed from Alum Treated Sludge Digestion.

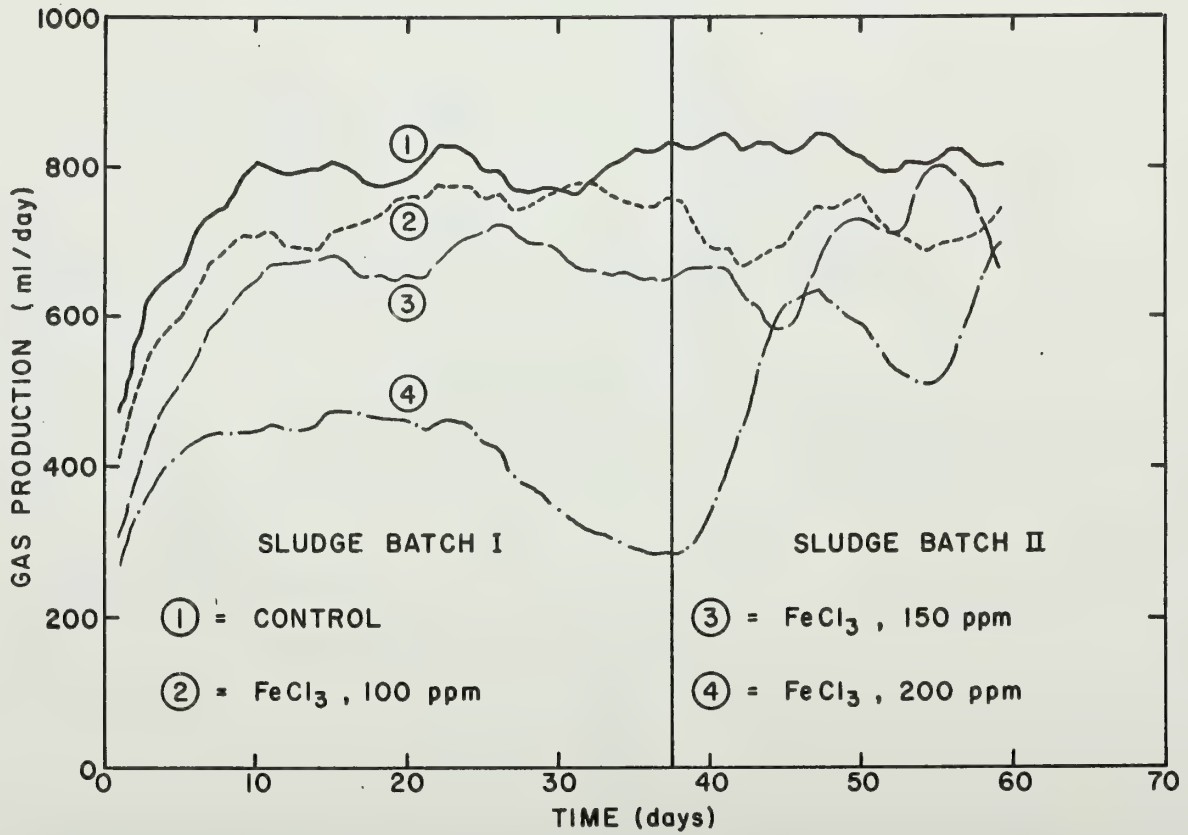

Figure 3. Daily Gas Production from Ferric Chloride Treated Sludge Digestion (5-Day Running Averages).

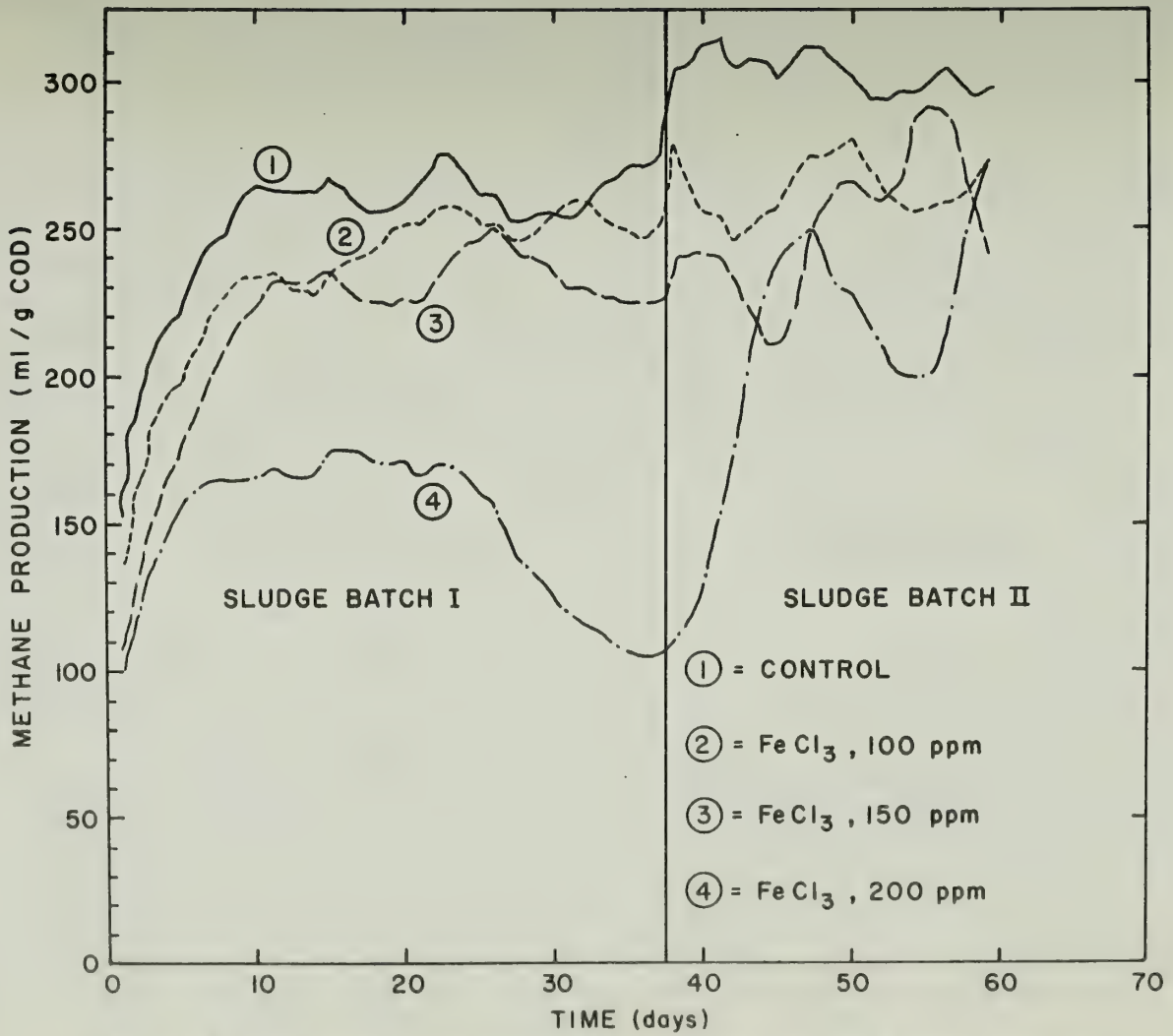

Figure 4. Daily Methane Production per Gram COD Fed from Ferric Chloride Treated Sludge Digestion.

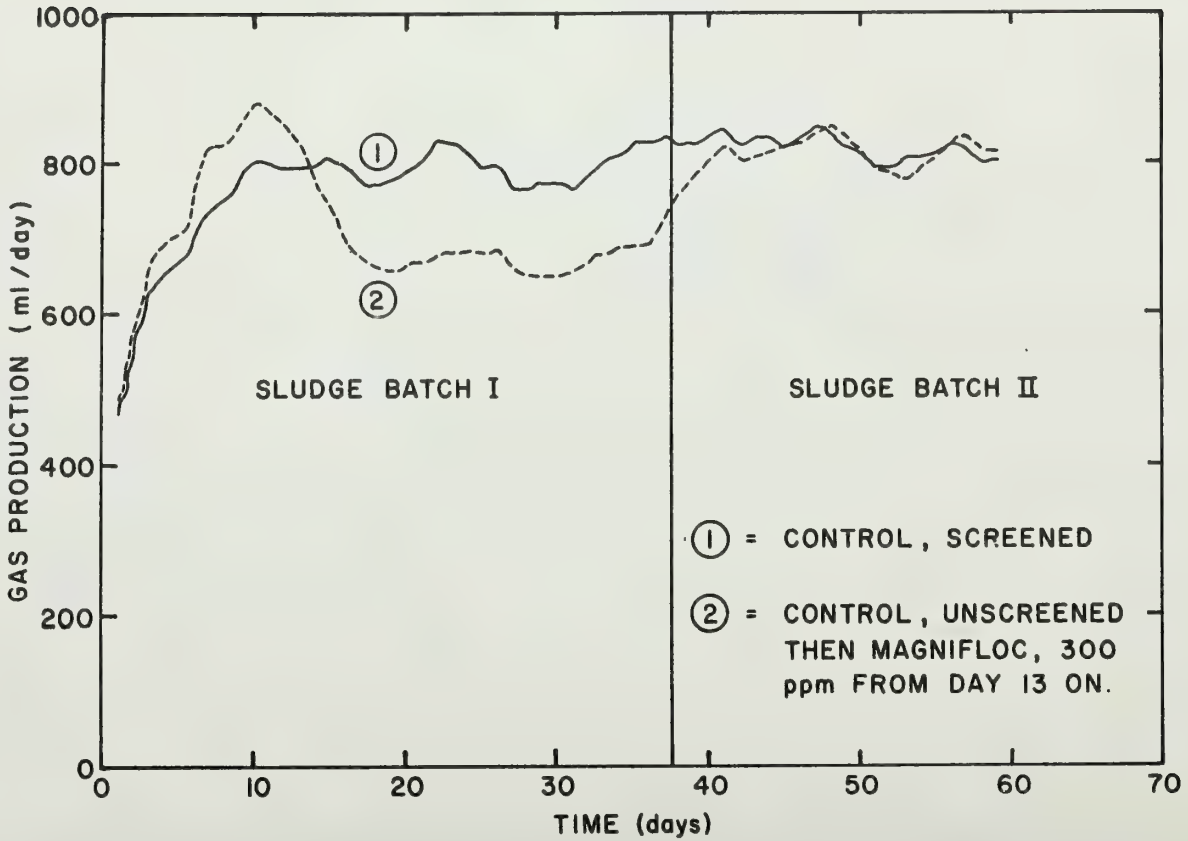

Figure 5. Daily Gas Production from Magnifloc Treated Sludge Digestion (5-Day Running Averages).

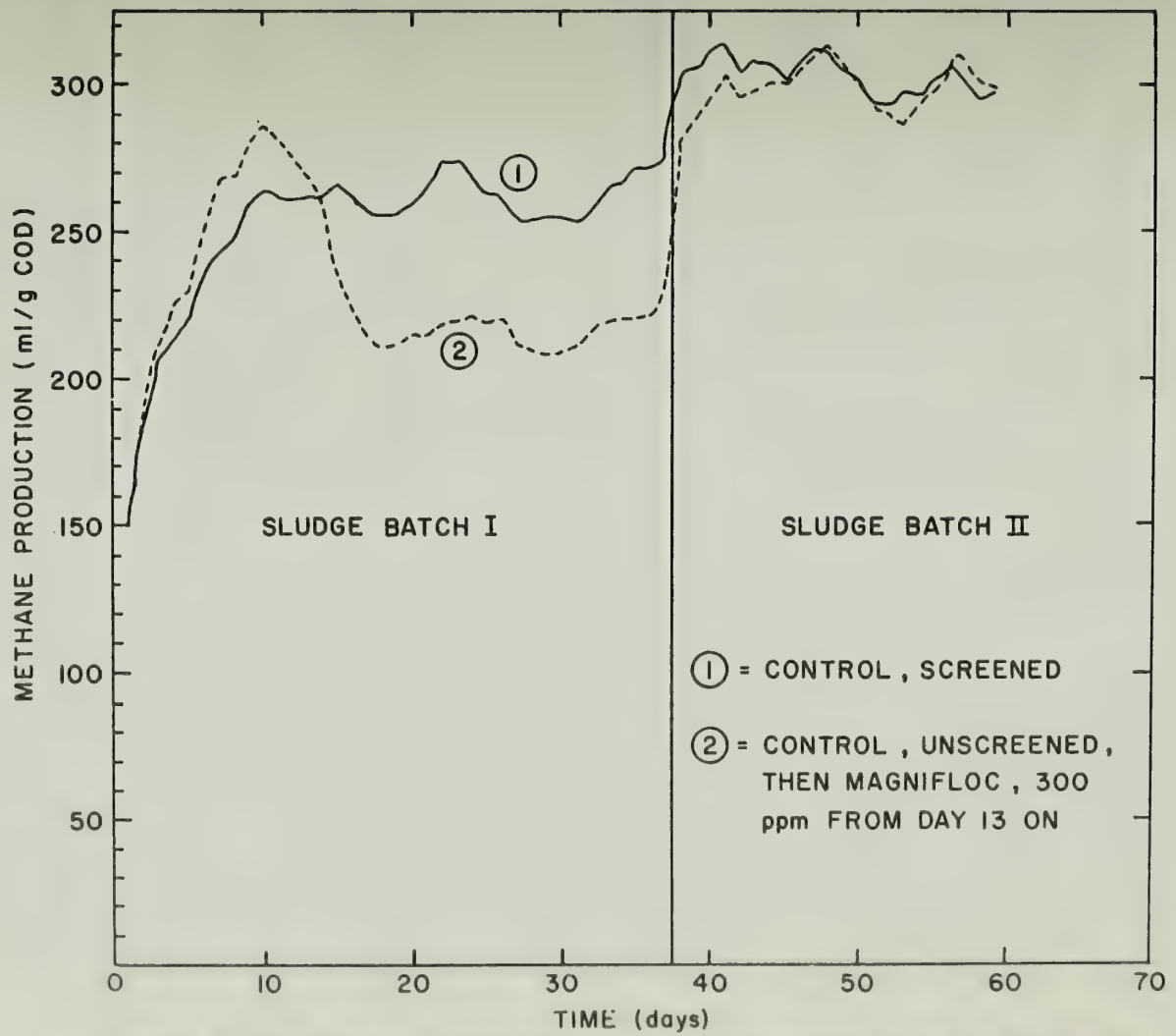

Figure 6. Daily Methane Production per Gram COD Fed from Magnifloc Treated Sludge Digestion.

differences in organic content and expressed as ml CH_4/g COD added (Figures 2 and 4). This effect is not typical of inhibition. Generally with inhibition the differences from a control will be minor until some threshold concentration of toxicant has been reached in the digester, yielding a subsequent deviation from the control. On the contrary, however, the results of this study support a hypothesis that either waste degradability or rates of utilization of alum and ferric-dosed sludges are lower than for control sludges. The question which needs answering is whether the COD data are good enough to term the differences between curves in Figures 2 and 4 "statistically significant". This question will be dealt with later.

Of all the sludges, only the $FeCl_3$, 200 ppm dosage, showed the typical signs of inhibition. Here, the volatile acid concentration rose to 1300 mg/l at the nadir of performance (near day 40), whereas the other digesters typically had concentrations less than 100 mg/l. For example, at day 45, the $FeCl_3$ 150 ppm digester was producing gas at a rate only 70% of the control, yet its volatile acid concentration was only 25 mg/l. This fact, plus the characteristic sudden drop in efficiency after proceeding at a level rate (observed after day 25), leads one to believe that the $FeCl_3$ 200 ppm reactor was experiencing toxicity. The rather phenomenal recovery made by this reactor upon feeding Batch II sludge of supposedly the same Fe content leads one to the conclusion that something quite different was causing problems in this reactor than was "inhibiting" the others. This means that observations of the $FeCl_3$ 200 ppm reactor are probably not indicative of what would ordinarily happen at that dose level in, say, eight out of ten experiments. Of course, the possibility of acclimation coincidentally occurring at the same time as feeding of Batch II sludge began cannot be eliminated with certainty.

At the end of the Batch I feeding period, the alum 150, 200, and 250 ppm digesters were performing at levels about 92, 85, and 81% of the control

digester, respectively, on a ml CH_4/g COD added basis. The ferric chloride 100, 150, and 200 ppm digesters were 96, 87, and 43% of control, respectively. Since the Magnifloc reactor did not have a proper control, its performance should not be compared with the control during Batch I feeding.

The alkalinity in the digesters ranged from 1900 mg/l (alum 250 ppm) to 2850 mg/l (ferric chloride 100 ppm) with a trend toward lower alkalinity with decreasing performance. Digester pH typically was 6.7 to 6.9, with the lower values encountered in digesters with lower efficiencies (due primarily to their lower alkalinities as mentioned above). The ferric chloride 200 ppm reactor had a pH of 6.6 at an alkalinity of 2200 mg/l--no doubt due to the high volatile acids content of that one reactor.

Upon beginning Batch II feeds, the control sludge's ml CH_4/g COD added rapidly increased (Figure 2). This is perhaps an indication that the biodegradable portion of the sludge had changed from Batch I to Batch II. Similar increases were observed for nearly all of the sludges (Figures 2, 4, and 6).

Interestingly enough, the alum 200 ppm and ferric chloride 200 ppm reactors indicated a lessened adverse effect between Batch I and Batch II, as evidenced by the characteristic rise to a peak at about day 45, with subsequent drop-off to some lower value, indicating the utilization of stored-up substrate.

As indicated in Figures 5 and 6, when a proper control for the Magnifloc 300 ppm sludge was provided, the performance was the same as the control as evidenced from day 38 onward.

During this period of feeding Batch II sludge, it was again noted that alum-fed reactors with lower efficiencies generally had lower alkalinities when compared with other reactors of the same type of chemical coagulant. Since the alkalinity in an anaerobic digester is due to activity of the acid-formers, the observations seem to support a hypothesis that these organisms are more affected than are the methane-formers by alum addition.

IV. DISCUSSION

A. Measurement of Performance. There are many different ways of describing digester performance. Theoretically, if all sludges are derived from the same wastewater, they should have a common degree of biodegradability; hence, if they all are adjusted to a fixed VS content of 2.5%, then total ml of gas per day might be a good indicator of performance. On the other hand, differences in methane composition might exist among the reactors. Hence, ml of methane per day should be considered a better indicator of performance, since the objective is waste stabilization, and methane production is directly correlated with waste stabilization.

On the other hand, it has been proposed that the presence of alum and ferric chloride might interfere with VS determination by holding waters of hydration through the preliminary heating step and releasing them in the subsequent ignition step, thus giving high values of VS and a false indication of the organic content. In that case, adjusting the feed sludges to 2.5% VS would mean there would be less organic content in the higher-dosed sludges than in the lower-dosed sludges. For this reason expressing performance as ml CH_4/g COD added would be a wiser choice. Unfortunately, the COD test has a coefficient of variation, V, of about 7% for sludge determinations, whereas the VS test has a V of only about 1%. Thus, choosing to express performance on a COD basis means trading inaccuracy for imprecision.

The validity of the proposed hypothesis that coagulants affect the accuracy of VS determinations was tested by running four replicates of each sludge for COD and VS, and examining the results to see if a statistically significant trend could be detected in the COD/VS ratio versus coagulant dosage for the sludges at the 5% level of significance. The results are presented in a separate paper (2). With the observed variance in COD data, it was not possible to detect what might be called an "experimentally important" trend as being a "statistically significant" one on the basis of only four

replicates. Consequently, no support of the hypothesis can be given--but this does not mean that the hypothesis is proven false, for to do so would require a minimum of 20 samples each for COD and VS determination.

One might choose to represent performance by VS reduction; however, not only would the potential problem of VS inaccuracy be confronted, but also the basic slow response of effluent characteristics to changes in efficiency would have to be reckoned with. The true level of treatment efficiency at any given moment can only be quantitatively determined on the basis of effluent characteristics after about 2 to 3 detention times have elapsed since the last system change has occurred. In other words, the reactor acts as a reservoir or capacitor. In a case where inhibition has existed and is suddenly removed by, for example, precipitation of the toxicant, the change will not be reflected quantitatively in VS or COD removal efficiencies (as measured by differences between influent and effluent values) until all the old contents have been removed, which from a practical standpoint, requires 2 to 3 detention times.

Because of the difficulty in finding a single best measure of digester performance, several of the discussed methods were used and are summarized in the following.

B. End-of-Study Performance. Table 1 shows the values of several reactor variables averaged over the last 10 days of digester operation. From these data, the conclusions for the study will be drawn.

There are six possible candidates for digester performance measurement: total gas, ml/day; total gas, ml/lb VS added; ml CH_4/day; ml CH_4/g COD added; VS destroyed; and COD destroyed. In Table 1, each of these values has been tabulated for each of the sludges, with the "percent of control" also reported.

C. Significance. What is desired is some indication of whether or not, for example, a methane production that is 93% of the control is a

TABLE 1

DATA SUMMARY (day 52 thru 61)

	Control Value	Alum, 200 ppm		Alum, 250 ppm		Alum, 325 ppm		$FeCl_3$, 100 ppm		$FeCl_3$, 150 ppm		$FeCl_3$, 200 ppm		Magnifloc 300 ppm	
		Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control
Gas Production															
Total ml/day	800	740	93	660	83	700	88	710	89	730	91	600	75	800	100
cu ft/lb VS added	10.8	9.59	89	8.52	79	9.00	83	9.27	86	9.38	87	7.90	73	10.4	96
cu ft/lb VS destroyed	16.4	16.0		16.1		16.1		15.7		15.6		18.0		16.0	
Methane															
ml/day	505	490	97	415	82	440	87	470	93	475	94	420	83	505	100
ml/gm COD added	295	270	92	240	81	265	90	260	88	265	90	240	81	295	100
ml/gm COD destroyed	475	475		470		520		490		500		750*		485	
Percent Methane	63	66		63		63		66		65		70		63	
Solids Balance															
Influent															
Total Solids, %	2.80	3.05		3.13		3.21		3.12		3.25		3.29		2.86	
Volatile Solids															
% of Waste	2.37	2.47		2.48		2.49		2.45		2.49		2.43		2.45	
% of Total Solids	85	81		79		78		79		77		74		86	
Effluent															
Total Solids, %	1.29	1.62		1.86		1.81		1.70		1.63		2.26		1.29	
Volatile Solids															
% of Waste	0.80	1.00		1.17		1.10		1.01		0.99		1.36		0.86	
% of Total Solids	62	62		63		61		59		61		60		67	
Volatile Solids Destroyed, %	66	60	91	53	80	56	85	59	89	60	91	44	67*	65	98
COD Balance															
Influent gm/l	34.2	36.2		34.5		33.1		35.8		35.5		35.1		34.2	
Effluent gm/l	13.1	15.4		16.8		16.3		16.7		16.8		24.0		13.5	
Destroyed, %	62	57	92	51	82	51	82	53	85	53	85	32	52*	61	98
Alk mg/l as $CaCO_3$	2450	2350		1800		1950		2700		2550		2350		2400	
Volatile Acids, mg/l	<100	<100		<125		<100		100-200		<100		100-200		<100	
pH	6.9	6.8		6.7		6.7		6.8		6.9		6.8		6.9	
Mean:			92%		81%		86%		88%		90%		78%		99%

*Not a good measure of performance, as performance was steadily improving, yielding other than true performance values based on effluent characteristics (which always lag behind present removal rates).

significant decrease. Toward this end, the one-sided t-Test at the 5% level of significance can be used. For the purpose of merely gaining a "feel" for the numbers involved, the data from the control digester can be employed to yield approximate variances for the data of the others.

For example, the mean gas production of the control for the last 10 days of operation was 802 ml/day, with an observed standard deviation, s, of 41 ml/day, and a coefficient of variation, V, of 5.1%. Likewise, the statistics of COD, VS, and other parameters can be found for the control. Subsequent propagation of error (assuming the methane composition is a deterministic constant) yields the following information (Table 2) on the control digester, but which shall be taken as approximately true for all digesters.

TABLE 2

Coefficients of Variation for
Selected Efficiency Parameters

Parameter	V (%)
Total gas--ml/day	5.1
cu ft/lb VS added	5.2
CH_4--ml/day	8.6
ml/g COD added	5.1
VS--% destroyed	1.4
COD--% destroyed	11.9

If it is assumed that such coefficients of variation are indicative of all the digesters, then the changes from control which are significant at the 5% level can be determined (See Appendix B for details). Such calculations give the results shown in Table 3 for performance indicators that do not depend upon effluent characteristics.

TABLE 3

Estimates of Significant Decreases from Control Digester Performance*

Parameter	Statistically significant level
ml gas/day	< 97% of control
cu ft gas/lb VS added	< 94% of control
ml CH_4/day	< 96% of control
ml CH_4/g COD added	< 89% of control

*5% level, one-sided t Test

The figures in Table 3 are only approximate, and rely on the assumptions of uniformity in the variance of a particular parameter among the eight reactors. But the data do indicate how such factors as COD influence precision and the increases in levels of deviation required for significance when COD is used as part of the efficiency measurement.

On the basis of Tables 1 and 3, it appears that all but the Magnifloc reactor show significant decreases from the control reactor performance. The alum sludge at 200 ppm is just barely in the range of significance. The 250 ppm and 325 ppm alum reactors show insignificant differences from each other, but significant decreases in performance from the alum 200 ppm digester.

The 100 ppm and 150 ppm ferric chloride reactors show insignificant deviations from each other, but significant decreases in performance compared to the control. The ferric chloride 200 ppm digester is significantly less efficient than either of the other two ferric reactors.

The basic 80-90% decreases from control efficiency observed in this study for the coagulant-dosed sludges correspond quite well to the observations of Hsu and Pipes (1) who investigated the effects of various levels of aluminum hydroxide on digester performance. When concentrations as high as 1550 mg/l Al were added to sludge, relative efficiencies of 80% of control

were noted in batch units at 35 deg C for 37 days. A direct comparison with this study cannot be made as the Al content of the sludges was not measured.

The theoretical value for ml CH_4/g COD destroyed at 35 deg C and one atmosphere is 395. All values in Table 1, however, are consistently higher than this value by about 20 percent. The high results may be attributable to COD measurement error and an increasing COD removal efficiency with time, or perhaps due to an inefficiency of the COD test, in measuring all the oxidizable organics present. In any event, the trends are similar to that of the other parameters, indicating a significant decrease in methane production resulting from addition either of alum or ferric chloride.

V. CONCLUSIONS

After 61 days of digestion, statistically significant decreases in digester performance were noted when sludges derived from alum-dosed (200-325 ppm) and $FeCl_3$-dosed (100-200 ppm) wastewater were fed, semi-continuously, to laboratory digesters operated at 15-day detention times. Performances varied from 80-90% of the control digester, with no apparent toxicity problems evident, such as volatile acid build-up or pH difficulty.

Even in the observed cases of greatest relative efficiency deficit, the treatment efficiency, if one were to ignore the control, is good. The least efficient reactor studied, that utilizing the $FeCl_3$ 200 ppm-derived sludge, for example, still evidenced about 8 cu ft of gas per lb of volatile solids added, which falls within the range considered "typical" (8-12 cu ft/lb VS added) for municipal digesters (3). Greater than 50% volatile solids destruction was observed for all cases where steady-state conditions were reached in the effluent.

Whether the statistically significant decreases in efficiency are operationally significant will depend, in part, upon the subsequent disposal methods

available for the digested sludge, as well as the extent to which the remaining volatile solids are capable of being further degraded after disposal (thus creating nuisance).

The extent to which the unutilized solids content difference between control and dosed sludges can be subsequently degraded if given sufficient time, could be determined by varying either the detention times of reactors, or by allowing a set of batch reactors to incubate for a long time, to approximate the degradation possible with greatly increased detention time. The results from such a study could shed some light on the mode of action of chemical coagulants on digester performance, and possibly answer the question of whether the effect is a kinetic one or not.

VI. REFERENCES

1. Hsu, D. Y., and Pipes, W. O., "Aluminum Hydroxide Effects on Wastewater Treatment Processes," Jour. Water Poll. Control Fed., 45, 4, 681 (1973).

2. Gossett, J. M., "Significance Testing of Observed COD/VS Ratios in Chemically Treated Sludges," unpublished paper, April (1974).

3. Metcalf and Eddy, Inc., Wastewater Engineering, New York, McGraw-Hill Book Co., 782 pp. (1972).

APPENDIX A

DETAILED DATA OF DIGESTER PERFORMANCE

Unit 1

Control (Screened)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		2.93	2.43	7.1	1600		0.85	0.57					
	1-21				7.1						170			
	1-22	39,840									360			
*	1-23				6.7					164	280	61	28	11
*	1-24										230			
	1-25				6.9	1600				120	395			
1	1-26				6.7						500			
2	1-27				6.7						615			
3	1-28				6.7	1650					565			
4	1-29				6.7					195	720			
5	1-30				6.7						730	62	38	0
6	1-31						8,680	0.85	0.52		620			
7	2-1				6.7	1850				163	695			
8	2-2										780			
9	2-3				6.7						855			
10	2-4	36,800	2.81	2.28							790			
11	2-5				6.7	1850					800			
12	2-6									128	785	64	36	0
13	2-7				6.7		10,870				750			
14	2-8							1.01	0.59		840			
15	2-9				6.8	2100					795			
16	2-10										810			
17	2-11				6.9					38	840			

*no feed previous day

Unit 1
Control (Screened)
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										695			
19	2-13										755	64	36	0
20	2-14				6.9	2200				55	765			
21	2-15						10,180	1.04	0.62		830			
22	2-16										880			
23	2-17										780			
24	2-18				6.9	2400					880			
25	2-19	39,110	2.84	2.30							765			
26	2-20				6.9	2400				~0	780			
27	2-21										770			
28	2-22				6.9	2450				26	785	64	36	0
29	2-23						10,190	1.08	0.65		740			
30	2-24										765			
31	2-25										795			
32	2-26				6.9	2400				26	765			
33	2-27										770			
34	2-28						14,770	1.41	0.86		805	64	36	0
35	3-1				6.8	2500				248	860			
36	3-2										840			
37	3-3										830			
38	3-4		2.91	2.50							770			
39	3-5				6.8	2500					865			
40	3-6		2.98	2.54						13	810			

Unit 1
Control (Screened)
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.9		15,120	1.41	0.85		845	63	37	0
42	3-8										910			
43	3-9										810			
44	3-10										735			
45	3-11				6.9	2500				13	860			
46	3-12										840			
47	3-13										820			
48	3-14						12,220	1.20	0.73		895			
49	3-15	32,010									820			
50	3-16										820			
51	3-17										755			
52	3-18				6.9	2400				26	770			
53	3-19										805			
54	3-20										815			
55	3-21										870			
56	3-22										750			
57	3-23	34,180	2.80	2.37							820	63	37	0
58	3-24				6.9	2450				13	865			
59	3-25										790			
60	3-26						13,070	1.29	0.80		765			
61	3-27										770			

Unit 2
Control (Unscreened)
Until 2/7, Magnifloc 509 C after at 300 ppm

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		2.87	2.50	7.1	1600								
	1-21				7.1						170			
	1-22	37,790									280			
*	1-23				6.8					140	330	58	32	10
*	1-24										240			
	1-25				6.9	1650				75	415			
1	1-26				6.6						525			
2	1-27				6.6						655			
3	1-28				6.6	1550					585			
4	1-29				6.7					195	655			
5	1-30				6.6						840	59	41	0
6	1-31						8,680	0.85	0.53		735			
7	2-1				6.6	1650				190	705			
8	2-2										915			
9	2-3				6.6						925			
10	2-4	36,700	3.04	2.55							850			
11	2-5				6.6	1650					890			
12	2-6									128	820	62	38	0
13	2-7				6.6		8,910				855			
14	2-8		3.25	2.50				0.88	0.53		825			
15	2-9				6.7	1900					705			
16	2-10										650			
17	2-11				6.8					114	655			

*no feed previous day

Unit 2
Magnifloc 509 C, 300 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										640			
19	2-13										685	66	34	0
20	2-14				6.8	2050				~0	650			
21	2-15						12,690	1.25	0.76		655			
22	2-16										700			
23	2-17										635			
24	2-18				6.8	2250					750			
25	2-19	40,840	3.22	2.45							660			
26	2-20				6.8	2250				25	690			
27	2-21										655			
28	2-22				6.9	2300				26	660	65	35	0
29	2-23						16,220	1.66	1.02		610			
30	2-24										630			
31	2-25										670			
32	2-26				6.8	2550				51	665			
33	2-27										705			
34	2-28						17,080	1.82	1.12		685	66	34	0
35	3-1				6.8	2400				326	665			
36	3-2										700			
37	3-3										685			
38	3-4		2.91	2.50							705			
39	3-5				6.7	2450					885			
40	3-6		3.16	2.72						51	830			

Unit 2
Magnifloc 509 C, 300 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.8		17,100	1.79	1.09		790	63	37	0
42	3-8										800			
43	3-9										810			
44	3-10										770			
45	3-11				6.8	2450				51	865			
46	3-12										835			
47	3-13										800			
48	3-14						16,350	1.56	0.99		875			
49	3-15	34,130									820			
50	3-16										920			
51	3-17										745			
52	3-18				6.9	2350				26	720			
53	3-19										745			
54	3-20										785			
55	3-21										885			
56	3-22										845			
57	3-23	34,250	2.86	2.45							775	63	37	0
58	3-24				6.9	2400				~0	850			
59	3-25										830			
60	3-26						13,540	1.29	0.86		790			
61	3-27										810			

Unit 3
Alum 150 ppm through 3-2-74
Alum 325 ppm from 3-3-74 onward

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		3.16	2.50	7.1	1680								
	1-21				7.1						160			
	1-22	36,680									320			
*	1-23				6.5					140	280	62	29	9
*	1-24										190			
	1-25				6.8	1600				120	350			
1	1-26				6.6						410			
2	1-27				6.6						510			
3	1-28				6.7	1500					480			
4	1-29				6.7					307	610			
5	1-30				6.8						630	63	37	0
6	1-31						12,870	1.22	0.73		560			
7	2-1				6.7	1650				203	625			
8	2-2										710			
9	2-3				6.7						800			
10	2-4	39,000	3.28	2.51							755			
11	2-5				6.8	1750					755			
12	2-6									153	750	64	36	0
13	2-7				6.8		11,470				795			
14	2-8							1.29	0.76		720			
15	2-9				6.8	2000					725			
16	2-10										725			
17	2-11				6.8					63	795			

*no feed previous day

Unit 3
Alum 150 ppm through 3-2-74
Alum 325 ppm from 3-3-74 onward
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										720			
19	2-13										685	64	36	0
20	2-14				6.8	2000				218	660			
21	2-15						13,140	1.47	0.86		715			
22	2-16										785			
23	2-17										695			
24	2-18				6.9	2050					740			
25	2-19	34,930	3.14	2.40							660			
26	2-20				6.9	2050				25	690			
27	2-21										725			
28	2-22				6.9	2050				26	710	64	36	0
29	2-23						16,830	1.71	0.99		645			
30	2-24										670			
31	2-25										725			
32	2-26				6.9	2100				77	700			
33	2-27										690			
34	2-28						18,620	1.60	0.96		700	63	37	0
35	3-1				6.8	1950				91	685			
36	3-2										740			
37	3-3										710			
38	3-4		3.21	2.50							665			
39	3-5				6.9	2150					670			
40	3-6		3.27	2.55						51	660			

Unit 3

Alum 325 ppm (from 3-3-74)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.9		13,740	1.69	1.00		685	63	37	0
42	3-8										640			
43	3-9										640			
44	3-10										600			
45	3-11				6.7	2050				26	705			
46	3-12										660			
47	3-13										650			
48	3-14						17,620	1.89	1.15		735			
49	3-15	36,510									685			
50	3-16										680			
51	3-17										695			
52	3-18				6.7	1950				51	830			
53	3-19										620			
54	3-20										645			
55	3-21										660			
56	3-22	33,140									660			
57	3-23		3.21	2.49							725	63	37	0
58	3-24				6.7	1950				115	715			
59	3-25										750			
60	3-26						16,340	1.81	1.10		715			
61	3-27										680			

Unit 4

Alum 200 ppm

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		3.29	2.50	7.0	1680								
	1-21				7.0						180			
	1-22	39,840									320			
*	1-23				6.6					47	280	60	27	13
*	1-24										160			
	1-25				6.8	1500				15	355			
1	1-26				6.7						440			
2	1-27				6.6						540			
3	1-28				6.7	1600					505			
4	1-29				6.7					112	615			
5	1-30				6.7						620	65	35	0
6	1-31						12,250	1.34	0.77		585			
7	2-1				6.7	1650				54	580			
8	2-2										635			
9	2-3				6.6						750			
10	2-4	39,200	3.24	2.39							640			
11	2-5				6.7	1800					605			
12	2-6									51	580	66	34	0
13	2-7				6.7		14,640				720			
14	2-8							1.68	0.95		670			
15	2-9				6.7	1850					685			
16	2-10										680			
17	2-11				6.8					25	665			

*no feed previous day

Unit 4
Alum 200 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.8		17,410	1.88	1.11		640	66	34	0
42	3-8										730			
43	3-9										800			
44	3-10										775			
45	3-11				6.7	2200				51	865			
46	3-12										770			
47	3-13										715			
48	3-14						15,710	1.73	1.04		740			
49	3-15	35,980									730			
50	3-16										755			
51	3-17										765			
52	3-18				6.8	2350				77	780			
53	3-19										740			
54	3-20										745			
55	3-21										740			
56	3-22	36,210									695			
57	3-23		3.05	2.47							755	66	34	0
58	3-24				6.8	2350				51	740			
59	3-25										755			
60	3-26						15,410	1.62	1.00		725			
61	3-27										715			

Unit 4
Alum 200 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										650			
19	2-13										665	65	35	0
20	2-14				6.8	1950				163	645			
21	2-15						15,500	1.69	0.97		675			
22	2-16										725			
23	2-17										690			
24	2-18				6.8	2100					775			
25	2-19	35,180	3.25	2.40							670			
26	2-20				6.8	2050				25	670			
27	2-21										665			
28	2-22				6.8	2000				26	685	65	35	0
29	2-23						19,000	1.85	1.05		630			
30	2-24										640			
31	2-25										695			
32	2-26				6.8	2300				26	660			
33	2-27										660			
34	2-28						18,150	1.90	1.11		660	64	36	0
35	3-1				6.7	2050				13	630			
36	3-2										685			
37	3-3										690			
38	3-4		3.09	2.50							610			
39	3-5				6.8	2000					595			
40	3-6		3.12	2.54						26	580			

Unit 5

Alum 250 ppm

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		3.24	2.43	7.0	1720								
	1-21				7.1						145			
	1-22	39,050									300			
*	1-23				6.6					117	250	60	27	13
*	1-24										140			
	1-25				6.8	1500				60	275			
1	1-26	-			6.7						380			
2	1-27				6.6						495			
3	1-28				6.6	1550					445			
4	1-29				6.6					307	525			
5	1-30				6.6						545	63	37	0
6	1-31						11,160	1.17	0.68		560			
7	2-1				6.6	1450				134	585			
8	2-2										595			
9	2-3				6.6						605			
10	2-4	35,600	3.22	2.36							580			
11	2-5				6.6	1500					555			
12	2-6									51	540	67	33	0
13	2-7				6.6		14,490				595			
14	2-8							1.58	0.91		610			
15	2-9				6.7	1550					585			
16	2-10										615			
17	2-11				6.7					38	670			

*no feed previous day

Unit 5
Alum 250 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										650			
19	2-13										625	64	36	0
20	2-14				6.7	1750				108	615			
21	2-15						14,170	1.67	0.95		650			
22	2-16										750			
23	2-17										695			
24	2-18				6.8	1950					760			
25	2-19	35,420	3.23	2.36							645			
26	2-20				6.8	2000				~0	630			
27	2-21										580			
28	2-22				6.8	2000				26	605	66	34	0
29	2-23						16,680	1.89	1.08		595			
30	2-24										615			
31	2-25										660			
32	2-26				6.7	1900				26	625			
33	2-27										595			
34	2-28						17,690	1.91	1.11		585	65	35	0
35	3-1				6.7	1750				13	595			
36	3-2										640			
37	3-3										615			
38	3-4		3.13	2.50							620			
39	3-5				6.6	1750					635			
40	3-6		3.23	2.58						38	660			

Unit 5
Alum 250 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.7		17,410	1.99	1.16		685	63	37	0
42	3-8										585			
43	3-9										605			
44	3-10										565			
45	3-11				6.7	2000				26	655			
46	3-12										610			
47	3-13										600			
48	3-14						18,410	1.95	1.19		655			
49	3-15	40,480									705			
50	3-16										740			
51	3-17										715			
52	3-18				6.7	1800				51	700			
53	3-19										665			
54	3-20										630			
55	3-21										600			
56	3-22	34,510									630			
57	3-23		3.13	2.48							760	63	37	0
58	3-24				6.7	1750				128	735			
59	3-25										670			
60	3-26						16,810	1.86	1.17		600			
61	3-27										570			

Unit 6

$FeCl_3$ 100 ppm

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		3.36	2.55	7.1	1550								
	1-21				7.1						140			
	1-22	38,735									290			
*	1-23				6.6					164	250	60	27	13
*	1-24										190			
	1-25				6.9	1600				136	355			
1	1-26				6.7						435			
2	1-27				6.6						535			
3	1-28				6.7	1800					500			
4	1-29				6.8					307	620			
5	1-30				6.8						640	64	36	0
6	1-31						12,710	1.41	0.82		610			
7	2-1				6.7	2100				138	620			
8	2-2										670			
9	2-3				6.7						810			
10	2-4	39,200	3.38	2.48							720			
11	2-5				6.8	2300					695			
12	2-6									153	630	66	34	0
13	2-7				6.7		20,680				695			
14	2-8							1.98	1.10		725			
15	2-9				6.7	2500					705			
16	2-10										670			
17	2-11				6.8					164	750			

*no feed previous day

Unit 6
$FeCl_3$ 100 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										740			
19	2-13										760	64	36	0
20	2-14				6.8	2550				305	750			
21	2-15						15,060	1.66	0.91		750			
22	2-16										800			
23	2-17										730			
24	2-18				6.8	2600					850			
25	2-19	39,360	3.36	2.46							740			
26	2-20				6.9	3100				51	735			
27	2-21										735			
28	2-22				6.9	2800				51	740	66	34	0
29	2-23						17,610	1.81	0.97		740			
30	2-24										765			
31	2-25										810			
32	2-26				6.9	2750				51	785			
33	2-27										785			
34	2-28						14,310	1.65	0.93		755	64	36	0
35	3-1				6.8	2950				13	700			
36	3-2										750			
37	3-3										750			
38	3-4		3.16	2.50							750			
39	3-5				6.7	2650					830			
40	3-6		3.18	2.55						38	690			

Unit 6
$FeCl_3$ 100 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.9		16,340	1.82	1.02		575	66	34	0
42	3-8										605			
43	3-9										740			
44	3-10										710			
45	3-11				6.8	2850				26	745			
46	3-12										635			
47	3-13	-									650			
48	3-14						17,460	1.82	1.06		870			
49	3-15	34,390									830			
50	3-16										720			
51	3-17										675			
52	3-18				6.8	2750				179	710			
53	3-19										730			
54	3-20										725			
55	3-21										650			
56	3-22	35,750									620			
57	3-23		3.12	2.45							740	66	34	0
58	3-24				6.8	2600				217	760			
59	3-25										750			
60	3-26						16,650	1.70	1.01		720			
61	3-27										725			

Unit 7

$FeCl_3$ 150 ppm

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		3.52	2.50	7.0	1460								
	1-21				7.1						160			
	1-22	39,370									310			
*	1-23				6.7					47	240	61	26	13
*	1-24										150			
	1-25				6.9	1900				169	210			
1	1-26				6.8						340			
2	1-27				6.8						410			
3	1-28				6.8	2850					405			
4	1-29				6.7					195	495	66	34	0
5	1-30				6.7						530			
6	1-31						11,160	1.30	0.71		530			
7	2-1				6.7	2150				469	575			
8	2-2										590			
9	2-3				6.7						695			
10	2-4	37,400	3.57	2.47							640			
11	2-5				6.7	2100					645			
12	2-6									204	655	66	34	0
13	2-7				6.7		12,680				715			
14	2-8							1.78	0.94		695			
15	2-9				6.7	2200					635			
16	2-10										665			
17	2-11				6.8					114	680			

*no feed previous day

Unit 7
$FeCl_3$ 150 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										650			
19	2-13										630	66	34	0
20	2-14				6.8	2250				110	635			
21	2-15						15,200	1.85	0.99		650			
22	2-16										700			
23	2-17										635			
24	2-18				6.8	2300					740			
25	2-19	37,390	3.56	2.46							735			
26	2-20				6.9	2350				51	720			
27	2-21										725			
28	2-22				6.9	2300				51	710	65	35	0
29	2-23						13,590	1.61	0.84		650			
30	2-24										670			
31	2-25										720			
32	2-26				6.8	2400				51	655			
33	2-27										635			
34	2-28						14,150	1.75	0.97		630	66	34	0
35	3-1				6.8	2350				143	645			
36	3-2										715			
37	3-3										635			
38	3-4		3.25	2.50							625			
39	3-5				6.7	2400					630			
40	3-6		3.36	2.58						26	680			

Unit 7
$FeCl_3$ 150 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.9		19,390	1.81	0.99		745	64	36	0
42	3-8										645			
43	3-9										615			
44	3-10										500			
45	3-11				6.9	2400				26	560			
46	3-12										580			
47	3-13										650			
48	3-14						17,620	1.97	1.15		770			
49	3-15	35,980									780			
50	3-16										760			
51	3-17										670			
52	3-18				6.9	2500				51	680			
53	3-19										700			
54	3-20										735			
55	3-21										860			
56	3-22										955			
57	3-23	35,490	3.25	2.49							770	65	35	0
58	3-24				6.9	2550				38	635			
59	3-25										645			
60	3-26						16,810	1.63	0.99		605			
61	3-27										680			

Unit 8

$FeCl_3$ 200 ppm

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	1-20		3.68	2.50	7.0	1600								
	1-21				7.1						150			
	1-22	38,735									270			
*	1-23				6.8					23	180	67	21	12
*	1-24										120			
	1-25				7.0	2000				~0	285			
1	1-26				6.8						280			
2	1-27				6.8						315			
3	1-28				6.8	2300					315			
4	1-29				6.7					195	455			
5	1-30				6.6						465	66	34	0
6	1-31						11,000	1.65	0.89		435			
7	2-1				6.7	1950				192	410			
8	2-2										420			
9	2-3				6.6						490			
10	2-4	35,800	3.68	2.45							460			
11	2-5				6.7	1900					440			
12	2-6									179	405	71	29	0
13	2-7				6.6		15,550				470			
14	2-8							2.38	1.28		465			
15	2-9				6.7	2000					455			
16	2-10										460			
17	2-11				6.7					265	500			

*no feed previous day

Unit 8
$FeCl_3$ 200 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	2-12										480			
19	2-13										440	68	32	0
20	2-14				6.7	2050				383	430			
21	2-15						15,500	2.27	1.28		450			
22	2-16										495			
23	2-17										425			
24	2-18				6.6	2200					495			
25	2-19	37,390	3.69	2.45							435			
26	2-20				6.7	2750				816	400			
27	2-21										400			
28	2-22				6.6	2200				744	380	69	31	0
29	2-23						19,610	2.18	1.23		335			
30	2-24										330			
31	2-25										340			
32	2-26				6.6	2300				1200	310			
33	2-27										300			
34	2-28						21,540	2.42	1.40		285	71	29	0
35	3-1				6.5	2150				1160	295			
36	3-2										290			
37	3-3										270			
38	3-4		3.38	2.50							270			
39	3-5				6.5	2450					290			
40	3-6		3.30	2.45						1277	295			

Unit 8
$FeCl_3$ 200 ppm
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	3-7				6.5		22,600	2.39	1.44		370	70	30	0
42	3-8										450			
43	3-9										540			
44	3-10										555			
45	3-11				6.7	2550				766	680			
46	3-12										665			
47	3-13										610			
48	3-14						20,950	2.27	1.39		620			
49	3-15	33,330									610			
50	3-16										575			
51	3-17										535			
52	3-18				6.9	2300				153	580			
53	3-19										500			
54	3-20										480			
55	3-21	35,070									485			
56	3-22										485			
57	3-23		3.29	2.43							595	70	30	0
58	3-24				6.8	2400				166	655			
59	3-25										765			
60	3-26						23,970	2.26	1.36		760			
61	3-27										700			

APPENDIX B

ORDER OF SIGNIFICANCE DETERMINATION

APPENDIX B--ORDER OF SIGNIFICANCE DETERMINATION (one-sided t Test, 5% level).

From the t Test parameter,

$$\Delta mean_s = t_{0.05, n_1+n_2-2}(S_o) \quad (1/n_1 + 1/n_2)^{1/2}$$

where $\Delta mean_s$ is the significant decrease in the mean, $t_{0.05, n_1+n_2-2}$ is the 5% t value for n_1+n_2-2 degrees of freedom, n_1 and n_2 are the number of samples of each of the two values being compared, and S_o is a composite standard deviation of values 1 and 2.

Gas--ml/day

$V = 5.1\%$, mean $\approx$ 700 ml/day

$S_o = 0.051\ (700) \approx 35$ ml/day

$n_1 = n_2 = 10$, $t_{0.05, 18} = 1.734$

therefore, $\Delta mean_s \approx 27$ ml/day

or $< 97\%$ of control is significant.

Gas--cu ft/lb VS added

$V = 5.2\%$, mean $\approx$ 10 cu ft/lb VS added

$S_o = 0.052\ (10) \cong 0.52$ cu ft/lb VS added

$n_1 = n_2 = 4$ (conservatively, as $n_1 = n_2 = 10$ for gas, and $n_1 = n_2 = 4$ for solids).

$t_{0.05, 6} = 1.943$

therefore, $\Delta mean_s \cong 0.7$ cu ft/lb VS added

or $< 94\%$ of control is significant.

Methane--ml/day

$V = 5.1\%$, mean $\approx$ 500 ml/day

$S_o = 0.051\ (500) \approx 25$ ml/day

$n_1 = n_2 = 10$

$t_{0.05, 18} = 1.734$

therefore, $\Delta mean_s \cong 19$ ml/day

or $< 96\%$ of control is significant.

Appendix B (Cont.)

Methane--ml/g COD added

$V = 8.6\%$, mean $\approx$ 270 ml/g COD added

$S_o = 0.086\ (270) \approx 23$ ml/g COD added

$n_1 = n_2 = 4$ (conservatively)

$t_{0.05,6} = 1.943$

therefore, $\Delta \text{mean}_s \approx 32$ ml/g COD added

or $< 89\%$ of control is significant.

APPENDIX H-4

CH2M/Hill
360 Pine Street
San Francisco, California 94104

PHASE II REPORT OF LABORATORY STUDY ON THE EFFECTS OF CHEMICAL COAGULANTS ON ANAEROBIC DIGESTION OF RICHMOND-SUNSET SLUDGE

by

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I. INTRODUCTION

The use of chemical coagulants to enhance suspended solids removal from municipal wastewater has been proposed for the City of San Francisco Richmond-Sunset facility. In a previous laboratory study, it was found that sludges derived from alum-dosed (200-325 mg/ℓ) and $FeCl_3$-dosed (100-200 mg/ℓ) wastewater produced a reduced gas production and volatile solids destruction equivalent to from 80-90% of that from a non-chemically derived control sludge. This reduced performance occurred in the absence of any apparent toxicity problems such as volatile acid build-up or pH difficulty. While the reduction in performance was small, there is concern over whether higher possible chemical dosages might cause system failure. Also, there was a desire to determine whether operation at longer detention times might improve volatile solids destruction in the chemically derived sludges. The following study to obtain additional information in order to help answer some of these concerns was conducted in response to a request from CH_2M/Hill dated April 17, 1974.

II. EXPERIMENTAL PROCEDURES

A. Digester Operation. The procedures followed in digester operation were similar to those outlined in the report of the initial study[1]. Six 750-mℓ laboratory digesters were fed sludge prepared under the direction of CH_2M/Hill personnel by dosing wastewater from the Richmond-Sunset Plant with various levels of alum and Magnifloc 509-C (an organic coagulant aide). Four digesters were operated with a 15-day detention time and two with a 30-day detention time. One of the four at 15-days received a control sludge (no chemical additions), and the other three received sludges which had been derived from chemical treatment of wastewater by addition of 325 mg/ℓ alum,

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[1] Gossett, J. M. and McCarty, P. L., "Laboratory Study on the Effects of Chemical Coagulants on Anaerobic Digestion of Richmond-Sunset Sludge, April 1974."

400 mg/ℓ alum, and 450-500 mg/ℓ Magnifloc 509-C, respectively. The two digesters at 30-days received the control sludge and the 325 mg/ℓ alum sludge, respectively.

The digesters were all initially started by seeding with 750-mℓ of digested sludge from the primary digester at the Richmond-Sunset Plant, and then were fed on a semi-continuous basis. For the first 6 days of operation, control sludge only was added to insure that all digesters were operating in a similar fashion. The addition of the different sludges was then begun. The digesters operated on a 15-day detention time were shaken each day, 50 mℓ was withdrawn, 50 mℓ of feed sludge was added, and the digesters were again shaken and left at 35°C until the next day when the procedure was repeated. The digesters operated on a 30-day detention time received similar treatment except 25-mℓ was withdrawn and added each day.

Gas production was recorded daily by measuring the displacement of an acid-salt solution in each of six 1500-mℓ calibrated tubes. Effluent pH, alkalinity, volatile acids, total and volatile solids, and chemical oxygen demand were measured regularly, as was gas composition (with a Fisher Gas Partitioner). On a few occasions after steady-state conditions of operation were obtained, organic and ammonia nitrogen concentrations in the feed sludges and withdrawn digested sludges were determined. Values for COD, total solids (TS), and volatile solids (VS) were obtained for at least four replicate samples of each feed sludge initially, near the middle of the study, and at the end of the study, to demonstrate that no significant changes in feed sludge composition had occurred during refrigerated storage.

B. Sludge Derivation. A single batch of each sludge was prepared prior to initiation of the study and was stored under refrigeration for the duration of the study. Each sludge was prepared at the Richmond-Sunset Plant

by addition of chemicals to the incoming wastewater and collecting a sample of the sludge which settled in the primary sedimentation tanks. Each of the four different sludges studied was prepared on one of four different consecutive days. This permitted collection of sludges as they would form under normal full-scale plant operation, but created the possibility that sludges may have been somewhat different in general characteristics.

The sludges were centrifuged to increase the total solids concentration to well over 4 percent, were transported to the laboratory where they were mixed with a blender, screened through 1/4-inch mesh to remove large particles which would interfere with feeding in laboratory units, and adjusted to 2.5% volatile solids concentration by addition of tap water. The sludges were each divided into two batches, one batch was frozen to preserve it for use during the second half of the 90-day study and the other batch was placed under refrigeration for use during the first half of the study.

III. RESULTS

Detailed operational data are contained in Appendix A. The total daily gas production data are summarized as five-day running averages in Figure 1. Table 1 contains a summary of the data obtained during the last 15 days of the study when steady-state conditions in all digesters should have been reached.

One significant aspect of the study was a significantly reduced alkalinity in the digesters receiving chemically derived sludges. Associated with this lower alkalinity was a lower pH than in the control units. In one digester, that receiving 400 mg/ℓ alum, the alkalinity by the 52nd day of operation dropped to a value of only about 1050 mg/ℓ as $CaCO_3$ at which time the pH dropped to 6.0. This pH was too low for the methane

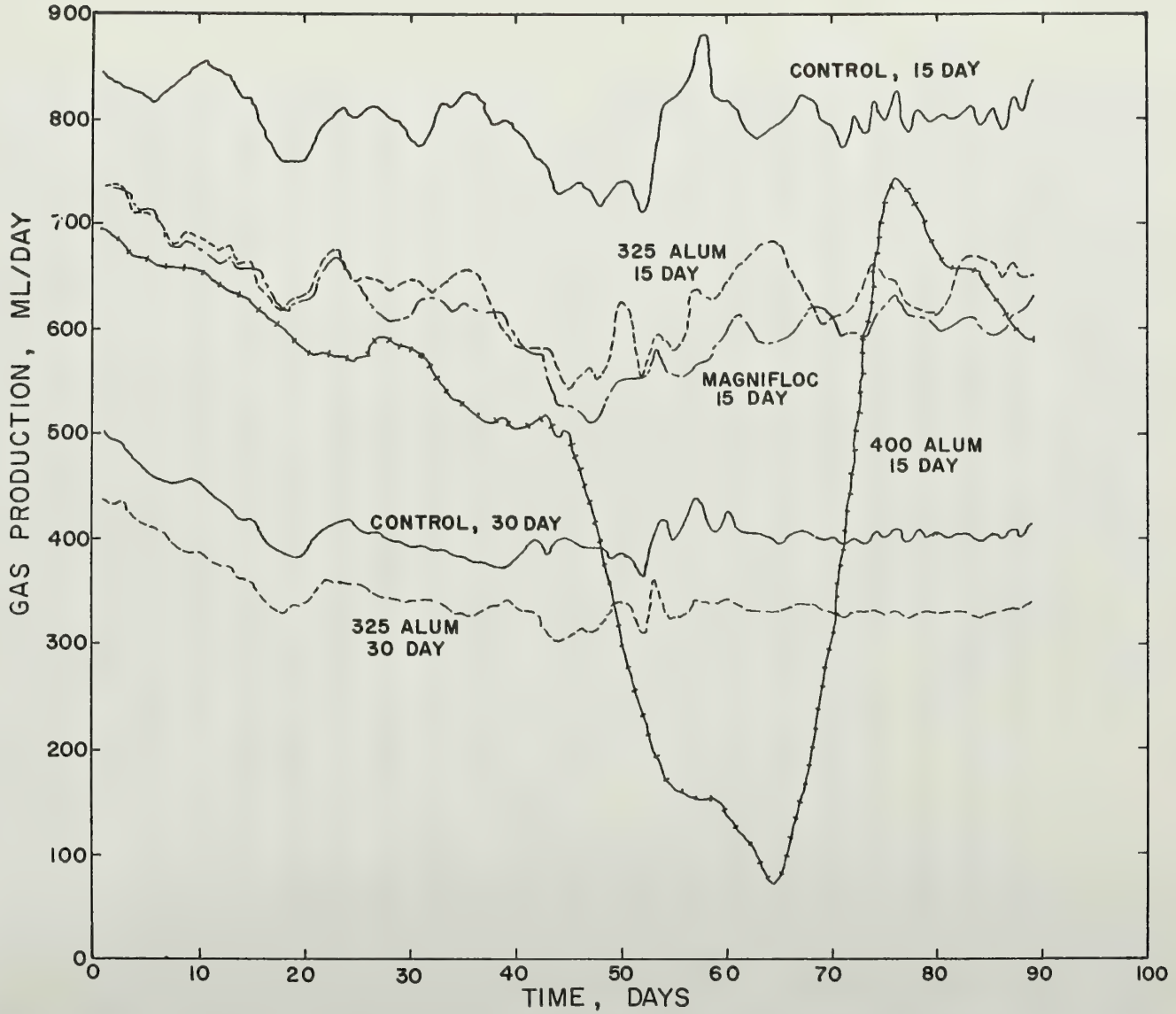


Figure 1. Daily Gas Production for Phase II Study (5-Day Running Averages).

TABLE 1

DATA SUMMARY (day 75 through 89)

	15-Day Detention Time							30-Day Detention Time		
		325 mg/ℓ Alum		400 mg/ℓ Alum		Magnifloc			325 mg/ℓ Alum	
	Control Value	Value	% of Control	Value	% of Control	Value	% of Control	Control Value	Value	% of Control
Gas Production										
Total mℓ/day	803	649	81	665	83	612	76	402	330	82
cu ft/lb VS added	10.3	8.2	80	8.4	82	8.3	81	10.3	8.4	82
cu ft/lb VS destroyed	16.4	17.1		17.8		17.2		16.1	17.4	
Methane										
mℓ/day	530	441	83	466	84	422	80	281	238	85
mℓ/gm COD added	280	232	83	256	91	240	86	298	251	84
mℓ/gm COD destroyed	480	464		548		488		487	478	
Percent Methane	66	68		70		69		70	72	
Solids Balance										
Influent										
Total Solids, %	3.28	3.30		3.73		3.09		3.28	3.30	
Volatile Solids										
% of Waste	2.49	2.52		2.54		2.37		2.49	2.52	
% of Total Solids	76	76		68		77		76	76	
Effluent										
Total Solids, %	1.62	2.12		2.53		1.99		1.70	2.14	
Volatile Solids										
% of Waste	0.91	1.32		1.39		1.23		0.90	1.31	
% of Total Solids	56	62		55		62		53	61	
Volatile Solids Destroyed, %	63	48	76	45	71	48	76	64	48	75
COD Balance										
Influent, g/ℓ	37.8	38.0		36.4		35.1		37.8	38.0	
Effluent, g/ℓ	15.7	19.0		19.4		17.8		14.7	18.1	
Destroyed, %	58	50	86	47	81	49	84	61	52	85
Alkalinity, mg/ℓ as $CaCO_3$	2600	2600*		2700*		2500*		2800	1800	
Volatile Acids, mg/ℓ	40	0		10		10		0	0	
pH	6.9	6.9		6.8		6.9		7.1	6.9	
Mean:			82%		82%		81%			82%

*Alkalinity raised by $NaHCO_3$ addition

producing bacteria with the result that failure occurred as evidenced by a markedly reduced gas production and an increase in volatile acid concentration to 1880 mg/ℓ. The alkalinity in the two other 15-day chemically fed digesters was also fairly low and so sodium bicarbonate was added to these three units to increase the alkalinity to near the 2500 mg/ℓ range of the control. This alkalinity was maintained for the remainder of the study.

In order to enhance the rate of recovery of the 400 mg/ℓ alum digester, feeding was discontinued for a few days and effluent from the control digester was added on three occasions for reseeding. By the 73rd day gas production had increased to normal and then exceeded normal while the accumulated organics were being fermented to methane. This digester had about reached steady-state operation again when the study was completed. The fact that digester operation recovered so rapidly once pH control was maintained indicates the failure resulted from low pH and not from the presence of inhibiting materials. The other digesters which received sodium bicarbonate never experienced any difficulty prior to or after the bicarbonate additions.

It was suspected that the reduced alkalinity in the digesters receiving chemically derived sludges resulted from reduced degradation of organic nitrogen containing compounds. The alkalinity in digested sludges results for the most part from ammonia nitrogen released by the degradation of these compounds. Ammonia in the presence of carbon dioxide and water forms ammonium bicarbonate as follows:

$$NH_3 + CO_2 + H_2O \rightarrow HCO_3^- + NH_4^+ \qquad (1)$$

This equation indicates that one mole or 14 grams of ammonia will form one equivalent or 50 grams of bicarbonate alkalinity.

Table 2 contains a summary of the organic and ammonia nitrogen concentrations in the various feed sludges and the digested sludges from this study. One point to be noted is the significantly different total nitrogen concentrations in the various feed sludges. These differences are also reflected in the total nitrogen analyses for the effluent sludges. These differences evidently reflect some of the differences between sludges derived on different days at the treatment plant. Fortunately, the total nitrogen content of the control sludge was bracketed by the total nitrogen content of the two alum derived sludges. Reduced conversion of organic nitrogen to ammonia in the chemically derived sludges is evidenced by the lower percentage reduction in organic nitrogen and lower percentage of ammonia nitrogen formation indicated in the last two columns in Table 2.

Table 3 is a summary of the alkalinity and ammonia nitrogen concentrations, and pH values just prior to sodium bicarbonate additions. Also included are calculated alkalinities associated with ammonia nitrogen for the different digesters based on Equation 1. Thus, ammonia nitrogen associated alkalinity was taken to equal the ammonia nitrogen concentration times the ratio 50/14. The ammonia nitrogen associated alkalinities in all cases were about 80 percent or more of the total alkalinities.

The data in Tables 2 and 3 indicate that the reduced alkalinity in the chemically derived sludges resulted from a reduced degree of degradation of organic nitrogen containing compounds. In addition, the very low relative alkalinity obtained in the 400 mg/ℓ alum digester resulted in part from a lower total nitrogen concentration in the feed. A similar reduced alkalinity with alum derived sludges was found in the previous study indicating the general nature of this effect.

TABLE 2

NITROGEN TRANSFORMATIONS DURING DIGESTION

Sludge	Detent. Time, Days	Nitrogen Content, mg/ℓ Feed Org	Feed NH_3	Feed Total	Effluent Org	Effluent NH_3	Effluent Total	Organic-N Decrease During Digestion mg/ℓ	Organic-N Decrease During Digestion %	Effluent NH_3-N, % of Total-N
Control	15	840	290	1130	580	600	1180	260	31	51
325 mg/ℓ Alum	15	1550	250	1800	1340	370	1710	210	14	22
400 mg/ℓ Alum	15	830	100	930	730	250	980	100	12	26
Magnifloc	15	1400	280	1680	1120	330	1450	280	20	23
Control	30	920	290	1210	600	640	1240	320	35	52
325 mg/ℓ Alum	30	1520	290	1810	1280	480	1760	240	16	27

TABLE 3

ALKALINITY, pH AND AMMONIA NITROGEN VALUES
PRIOR TO BICARBONATE ADDITIONS

Sludge	Detention Time, Days	Effluent Analyses, mg/ℓ			NH_3-N Associated Alkalinity	
		pH	Alkalinity as $CaCO_3$	Ammonia Nitrogen	mg/ℓ	% of Total Alkalinity
Control	15	7.0	2600	600	2140	82
325 mg/ℓ Alum	15	6.4	1250	330	1180	94
400 mg/ℓ Alum	15	6.0	1050	230	820	78
Magnifloc	15	6.5	1200	320	1140	95
Control	30	7.1	2700	650	2320	86
325 mg/ℓ Alum	30	6.9	1900	480	1710	90

Concerning other aspects of the study, the data contained in Table 1 reveal very similar results to that obtained in the previous study. Based upon total gas production, methane production, volatile solids and COD destruction, the destruction of organic materials in chemically derived sludges were only about 82 percent as great as in non-chemically derived sludges. This is a real and significant reduction, based on the statistical analyses given in the previous report. With alum, the results from this study with sludges derived by addition of 325 mg/ℓ and 400 mg/ℓ alum were almost identical to the previous results using 250 mg/ℓ alum. In addition, contrary to expectations, results from operation at a 30-day detention time were not significantly different from operation at a 15-day detention time.

One difference noted in this study compared with the previous study was with Magnifloc derived sludges. In the previous study there was no significant difference in relative performance between 300 mg/ℓ Magnifloc derived sludges and the control sludges. However, in this study using 400 mg/ℓ to 500 mg/ℓ of Magnifloc, performance was only about 81 percent of the control performance. The higher dosage of Magnifloc appears to have caused a significant difference. This difference was also reflected in reduced degradation of organic nitrogen containing compounds and associated alkalinity.

An additional aspect worthy of comment is the methane production per gram of COD destroyed listed in Table 1. As with the previous study, the values generally were in the range of 470 to 490 mℓ CH_4/g COD destroyed. These values are about 20 percent higher than the theoretical value of 395 mℓ/g destroyed for 35°C operation. About 7 percent of the discrepancy results from our failure to consider the water vapor portion of the gas produced. The other 13 percent is believed to result largely from the inability of the COD test to measure 100 percent of the organics in sludges.

IV. NATURE OF CHEMICAL EFFECT

One of the questions of interest in this study was the cause of the reduced organic degradation of sludges resulting from chemical treatment of wastewater. As in the previous study, there was no outward signs of toxicity in the digestion of chemical sludges. Except for the 400 mg/ℓ alum sludge which experienced failure because of a low pH, the volatile acids concentrations generally remained below 200 mg/ℓ and the percentage of methane was approximately the same in all units. Also, the reduction in gas production was noted from the first day after chemically derived sludges were added to the digesters. Such would not be the case if the effect were a toxic one. With toxic materials, reduced gas production would be noted only after the concentration of toxic material exceeds a threshold value, and then the effect would be quite marked on performance. Thus, toxicity from the alum or Magnifloc is not indicated. Rather, the effect appears to be one which reduces the biodegradability of the sludge organics, especially the organic nitrogen containing compounds.

It was desired to determine whether the reduction in biodegradability was an absolute reduction or whether it simply decreased the rate at which the organics were degraded. In order to help answer this question, two studies were undertaken. One was operation of digesters both at a 15-day and a 30-day detention time. The results summarized in Table 1 indicate reduction of organics with 30-day operation was no greater than from operation at a 15-day detention time, both for the control and for the 325 mg/ℓ alum sludge. Thus, these data suggest that the reduction was not kinetic in nature, but was an absolute reduction in the degree of biodegradability of the sludge.

The second study conducted to determine the nature of the reduction was a continuation of the first study. Here, after completion of the previous study, the digesters containing the digested sludge from semi-continuous operation at a 15-day detention time were allowed to set for up to 110 days with no additional sludge feed. During this time, the sludge continued to decompose. It was believed that if the effect of chemical treatment was kinetic in nature, then the organic matter in the chemically derived sludges would decrease more rapidly and approach the organic content of the control sludge with time. Table 4 is a summary of the results from this study. The sludge was analyzed at two times, once after an additional 35 days of decomposition and once after 110 days of decomposition. The results shown are averages of four separate analyses on each sludge.

The results indicate the chemically derived sludges did decompose at a somewhat higher rate than the control sludges so that the differences in organic content became smaller with time. This suggests that the effect of chemical treatment was to some degree kinetic in nature. However, the results from the detention time study during Phase II indicates that the kinetic effect is not significant enough to cause a noticeable difference in performance when the detention times differ by no more than 15 and 30 days.

CONCLUSIONS

The results from the first study and from the present Phase II study on digestion of chemically derived sludges lead to similar conclusions.

1. Digestion with a 15 to 30-day detention time of sludges produced from addition of 250 to 400 mg/ℓ of alum to municipal wastewater at the Richmond-Sunset treatment plant is only about 80 to 82 percent as complete as digestion of primary settled sludge without chemical additions.

TABLE 4

EXTENT OF DEGRADATION OF PHASE 1

DIGESTED SLUDGES AS A FUNCTION OF TIME

	Control	Alum, 200 mg/ℓ		Alum, 250 mg/ℓ		Alum, 325 mg/ℓ		$FeCl_3$, 100mg/ℓ		$FeCl_3$,150 mg/ℓ		$FeCl_3$,200 mg/ℓ		Magnifloc,300 mg/ℓ	
	Value	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control	Value	% of Control
Influent To Digestion															
Total Solids, %	2.80	3.05		3.13		3.21		3.12		3.25		3.29		2.86	
Volatile Solids															
% of Waste	2.37	2.47		2.48		2.49		2.45		2.49		2.43		2.45	
% of Total Solids	85	81		79		78		79		77		74		86	
Effluent From Digester															
Total Solids, %	1.29	1.62		1.86		1.81		1.70		1.63		2.26		1.29	
Volatile Solids															
% of Waste	0.80	1.00		1.17		1.10		1.01		0.99		1.36		0.86	
% of Total Solids	62	62		63		61		59		61		60		67	
Volatile Solids Destroyed	66	60	91	53	80	56	85	59	89	60	91	44	67	65	98
Effluent - 35 Days Degradation															
Total Solids, %	1.33	1.43		1.71		1.61		1.48		1.53		2.22		1.43	
Volatile Solids															
% of Waste	0.78	0.83		0.97		0.91		0.80		0.79		1.12		0.86	
% of Total Solids	58	58		57		57		54		52		50		60	
Volatile Solids Destroyed	67	66	99	61	91	63	94	67	100	68	101	54	81	65	97
Effluent - 110 Days Degradation															
Total Solids, %	1.19	1.39		1.48		1.59		1.42		1.49		2.18		1.31	
Volatile Solids															
% of Waste	0.67	0.77		0.80		0.87		0.75		0.74		0.96		0.76	
% of Total Solids	56	55		54		55		53		49		44		58	
Volatile Solids Destroyed	72	69	96	68	94	65	90	69	96	70	97	60	83	69	96

2. Digestion of sludges resulting from addition of 450 to 500 mg/ℓ of Magnifloc 509C were also only 82 percent as complete as digestion of non-chemically derived sludges, but this effect was not noted in the first study when 300 mg/ℓ Magnifloc was used.

3. The reduced performance with chemically derived sludges is manifested in reduced total gas production, total methane reduction, COD reduction, and volatile solids destruction; but not in gas or methane production per unit mass of volatile solids or COD destroyed nor in gas composition.

4. An even greater reduction in degradation of organic nitrogen containing compounds of more than 50 percent occurred during digestion of chemically derived sludges; this resulted in lower alkalinities in chemically derived sludges and a reduced pH buffer capacity against digester upset.

5. Chemical additions did not cause a toxic effect, but reduced the biodegradability of certain organic materials, especially those containing nitrogen.

6. Operation with a 30-day compared with a 15-day detention time did not increase significantly the extent of organic degradation of chemically derived sludges.

7. Whether the decreases in organic degradation are operationally important will depend, in part upon the subsequent disposal methods and the effect of the increased quantities of organic matter remaining in chemically derived digested sludges on the cost and feasibility of disposal.

APPENDIX

DETAILED DATA OF DIGESTER PERFORMANCE

Unit 1
Control
15-Day Detention Time

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	4-25	37,900	3.44	2.64							650			
	4-26				6.7	2,750				28	875			
	4-27										-			
	4-28				6.7		29,600				1,020			
	4-29							4.34	2.47		980			
	4-30				6.7						990			
1	5-1										835			
2	5-2										840			
3	5-3				6.8	2,600				28	855			
4	5-4										810			
5	5-5	34,900	3.35	2.55			34,000				810			
6	5-6				6.8						820			
7	5-7				6.7			3.59	2.01		815			
8	5-8				6.7						810			
9	5-9				6.7	2,650				28	860			
10	5-10										870			
11	5-11										865			
12	5-12				6.7		32,700				850			
13	5-13				6.7						830			
14	5-14							2.87	1.63		810			
15	5-15										845			
16	5-16										770			
17	5-17				6.7	2,600				41	850			

Unit 1
Control
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	5-18						24,300				670			
19	5-19										740			
20	5-20				6.8			2.35	1.28		760			
21	5-21										770			
22	5-22										855	71.5	28.5	
23	5-23										790			
24	5-24				6.9	2,750				40	820			
25	5-25										795			
26	5-26						27,800				800			
27	5-27				6.8			2.06	1.13		795			
28	5-28										835			
29	5-29										830			
30	5-30										750			
31	5-31				6.9	2,750				0	770	70.5	29.5	
32	6-1										710			
33	6-2	36,300	3.28	2.51			18,200				800			
34	6-3				6.9			1.90	1.03		915			
35	6-4										880			
36	6-5										750	70	30	
37	6-6										775			
38	6-7										800			
39	6-8						15,300				870			
40	6-9				7.0	2,700				28	770			

Unit 1
Control
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	6-10							1.94	1.05		780			
42	6-11				6.9						740			
43	6-12										750	69	31	
44	6-13	36,900	3.23	2.47							770			
45	6-14										740			
46	6-15				6.9	2,600				193	640			
47	6-16										760			
48	6-17						13,200				780			
49	6-18				6.9						750			
50	6-19							1.69	0.93		640			
51	6-20										710	67	33	
52	6-21				6.9	2,500					830			
53	6-22									125	770			
54	6-23										600			
55	6-24										770			
56	6-25							1.64	0.90		1090			
57	6-26				6.8						860			
58	6-27				7.2	2,440	14,800			137	820	65	32	3
59	6-28										770			
60	6-29										860			
61	6-30										780			
62	7-1							1.56	0.83		850			
63	7-2						14,100				770	67	33	0

Unit 1
Control
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
64	7-3				6.9	2,550				26	680			
65	7-4							1.58	.85		830			
66	7-5						14,600				810			
67	7-6										880			
68	7-7										820			
69	7-8							1.66	.92		770			
70	7-9						13,500				810	65.7	33.9	.4
71	7-10				7.2	2,700				54	700			
72	7-11							1.56	.85		870			
73	7-12						13,900				710			
74	7-13										920			
75	7-14										720			
76	7-15							1.46	.72		860			
77	7-16						14,400				770			
78	7-17				6.9	2,600				56	870			
79	7-18							1.61	.86		710			
80	7-19						14,200				830			
81	7-20										810			
82	7-21										790			
83	7-22							1.87	1.01		880			
84	7-23						14,200				700			
85	7-24				6.9	2,650					880	66	34	0
86	7-25							1.68	.91		720			
87	7-26						17,500				870			
88	7-27										770			
89	7-28	36,700	3.13	2.33	6.9	2,600	16,000	1.59	.95	26	870			

Unit 2
325 mg/ℓ Alum
15-Day Detention Time

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	4-25	37,900	3.44	2.64							720			
	4-26				6.7	2,600				14	920			
	4-27										-			
	4-28				6.7		32,800				950			
	4-29							4.53	2.61		930			
	4-30				6.7						970			
1	5-1										780			
2	5-2										695			
3	5-3				6.7	2,650				14	720			
4	5-4										750			
5	5-5	37,000	3.44	2.64			30,000				725			
6	5-6				6.6			3.67	2.14		660			
7	5-7				6.6						690			
8	5-8				6.6						700			
9	5-9				6.6	2,000				162	680			
10	5-10										665			
11	5-11										715			
12	5-12				6.5		26,500				670			
13	5-13				6.5						680			
14	5-14							3.03	1.83		640			
15	5-15										680			
16	5-16										635			
17	5-17				6.5	1,750				13	675			

Unit 2
325 mg/ℓ Alum
15-Day Detention Time
(Continued)

	INFLUENT				EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	5-18						25,500				565			
19	5-19										580			
20	5-20				6.5			2.71	1.66		625			
21	5-21										695			
22	5-22										690	73	27	
23	5-23										635			
24	5-24				6.5	1,750				26	690			
25	5-25										665			
26	5-26						28,800				620			
27	5-27				6.6			2.45	1.50		610			
28	5-28										650			
29	5-29										680			
30	5-30										620			
31	5-31				6.4	1,550				0	640	72.5	27.5	
32	6-1										635			
33	6-2	36,800	3.31	2.54			21,200				640			
34	6-3				6.6			2.32	1.46		625			
35	6-4										655			
36	6-5										685	70	30	
37	6-6										670			
38	6-7										630			
39	6-8						19,600				580			
40	6-9				6.6	1,450				26	525			

Unit 2
325 mg/ℓ Alum
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	6-10							2.28	1.42		570			
42	6-11				6.5						605			
43	6-12										620	70.5	29.5	
44	6-13	37,800	3.25	2.50							590			
45	6-14										520			
46	6-15				6.6	1,400				26	480			
47	6-16										490			
48	6-17						19,700				670			
49	6-18				6.45						650			
50	6-19							2.31	1.47		470			
51	6-20										640	68	32	
52	6-21				6.4	1,250					700			
53	6-22									25	590			
54	6-23										360			
55	6-24						20,000				660			
56	6-25							2.30	1.51		650			
57	6-26				6.5						620			
58	6-27				6.5	1,450				0	650	67	30	3
59	6-28										600			
60	6-29										620			
61	6-30										640			
62	7-1	$NaHCO_3$ additions begun						2.14	1.33		690			
63	7-2						20,300				750	65.6	33.9	.5

Unit 2
325 mg/ℓ Alum
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
64	7-3				6.9	2,400				26	630			
65	7-4							2.12	1.23		680			
66	7-5						19,700				660			
67	7-6										680			
68	7-7										640			
69	7-8							2.19	1.35		550			
70	7-9						19,000				580	69.9	29.2	.9
71	7-10				7.3	2,600				27	570			
72	7-11							2.11	1.27		700			
73	7-12						18,600				660			
74	7-13										580			
75	7-14										710			
76	7-15							1.87	1.02		660			
77	7-16						19,500				630			
78	7-17				6.9	2,500				0	640			
79	7-18							2.19	1.35		480			
80	7-19						20,300				680			
81	7-20										650			
82	7-21										600			
83	7-22							2.06	1.24		710			
84	7-23						18,300				660			
85	7-24				6.9	2,600					720	66	34	0
86	7-25							2.14	1.65		640			
87	7-26						18,500				590			
88	7-27										630			
89	7-28	38,800	3.24	2.45	6.8	2,500	18,900	2.17	1.32		730			

Unit 3
400 mg/ℓ Alum
15-Day Detention Time

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	4-25	37,900	3.44	2.64							465			
	4-26				6.7	2,400				14	800			
	4-27										-			
	4-28				6.7		37,320				945			
	4-29							4.57	2.62		925			
	4-30				6.7						965			
1	5-1										740			
2	5-2										660			
3	5-3				6.8	2,500				28	685			
4	5-4	36,400	3.78	2.59							670			
5	5-5						34,000				655			
6	5-6				6.6			3.70	2.11		675			
7	5-7				6.6						655			
8	5-8				6.6						650			
9	5-9				6.6	2,250				54	650			
10	5-10										660			
11	5-11										665			
12	5-12				6.5		31,700				645			
13	5-13				6.5						635			
14	5-14							3.27	1.87		610			
15	5-15										620			
16	5-16										550			
17	5-17				6.5	1,750				13	625			

Unit 3
400 mg/ℓ Alum
15-Day Detention Time
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	5-18						29,900				580			
19	5-19										560			
20	5-20				6.4			3.03	1.67		595			
21	5-21										595			
22	5-22										585	73	27	
23	5-23										530			
24	5-24				6.5	1,500				25	570			
25	5-25										575			
26	5-26						28,000				600			
27	5-27				6.4			2.86	1.58		570			
28	5-28										575			
29	5-29										640			
30	5-30										570			
31	5-31				6.4	1,350				0	575	72	28	
32	6-1										555			
33	6-2						24,000				555			
34	6-3				6.4			2.79	1.57		545			
35	6-4										510			
36	6-5										500	71	29	
37	6-6										520			
38	6-7										520			
39	6-8						22,100				510			
40	6-9	36,400	3.86	2.66	6.4	1,200				105	490			

Unit 3
400 mg/ℓ Alum
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	6-10							2.79	1.56		540			
42	6-11				6.3						460			
43	6-12										535	70.5	29.5	
44	6-13	35,100	3.68	2.49							530			
45	6-14										530			
46	6-15				6.4	1,150				131	420			
47	6-16										510			
48	6-17						21,000				360			
49	6-18				6.2						330			
50	6-19							2.75	1.62		340			
51	6-20										240	69	31	
52	6-21				6.0	1,050					240			
53	6-22									425	190			
54	6-23										130			
55	6-24						21,500				170			
56	6-25	$NaHCO_3$ additions begun						2.75	1.58		130			
57	6-26				6.4						190			
58	6-27				6.5	2,200				924	160	59	32	9
59	6-28										110			
60	6-29										160			
61	6-30										140			
62	7-1							2.90	1.69		130			
63	7-2						27,600				80	52.5	36.1	9.8

Unit 3
400 mg/ℓ Alum
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
64	7-3				6.4	2,200				1,880	60			
65	7-4							3.04	1.82		50			
66	7-5						27,900				40			
67	7-6										140			
68	7-7										210			
69	7-8							2.66	1.51		260			
70	7-9						24,200				330	69	27	4
71	7-10				7.2	2,700				136	350			
72	7-11							2.76	1.56		460			
73	7-12						22,800			134	570			
74	7-13										720			
75	7-14										780			
76	7-15										770			
77	7-16						20,000				700			
78	7-17				6.9	2,650				28	740			
79	7-18										660			
80	7-19						18,500				680			
81	7-20										620			
82	7-21										620			
83	7-22							2.54	1.38		700			
84	7-23						18,100				650			
85	7-24				6.8	2,700					690	67	32.5	.5
86	7-25							2.49	1.35		610			
87	7-26						18,900				570			
88	7-27										590			
89	7-28	37,500	3.68	2.46	6.8	2,600	19,500	2.54	1.40	0	600			

Unit 4
450-500 mg/ℓ Magnifloc
15-Day Detention Time
(Continued)

	INFLUENT				EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	4-25	37,900	3.44	2.64							760			
	4-26				6.7	2,450				14	940			
	4-27										-			
	4-28				6.7		32,200				905			
	4-29							4.52	2.53		930			
	4-30				6.7						980			
1	5-1										775			
2	5-2										665			
3	5-3				6.7	2,500				28	730			
4	5-4	36,250	3.26	2.52							765			
5	5-5						32,700				735			
6	5-6				6.6			3.55	2.06		650			
7	5-7				6.6						690			
8	5-8				6.6						700			
9	5-9				6.6	2,100				27	665			
10	5-10										665			
11	5-11										695			
12	5-12				6.5		31,300				660			
13	5-13				6.5						660			
14	5-14							2.91	1.75		635			
15	5-15										685			
16	5-16										635			
17	5-17				6.5	1,750				13	675			

Unit 4
450-500 mg/ℓ Magnifloc
15-Day Detention Time
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	5-18						23,200				590			
19	5-19										570			
20	5-20				6.5			2.59	1.57		600			
21	5-21										675			
22	5-22										690	73.5	26.5	
23	5-23										650			
24	5-24				6.5	1,650				26	675			
25	5-25										645			
26	5-26						27,000				640			
27	5-27				6.6			2.33	1.43		620			
28	5-28										560			
29	5-29										605			
30	5-30										605			
31	5-31				6.5	1,650				0	645	73	27	
32	6-1										635			
33	6-2						19,000				650			
34	6-3				6.6			2.19	1.39		610			
35	6-4										580			
36	6-5										610	72	28	
37	6-6										670			
38	6-7										620			
39	6-8						18,600				600			
40	6-9	35,200	3.25	2.52	6.6	1,450				290	580			

Unit 4
450-500 mg/ℓ Magnifloc
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	6-10							2.18	1.37		570			
42	6-11				6.6						555			
43	6-12										600	71.5	28.5	
44	6-13	32,550									570			
45	6-14		3.23	2.47							470			
46	6-15				6.5	1,300				0	450			
47	6-16										540			
48	6-17						18,700				580			
49	6-18				6.5						520			
50	6-19							2.04	1.29		490	69.4	30.6	
51	6-20										580			
52	6-21				6.5	1,200					600			
53	6-22									0	580			
54	6-23										520			
55	6-24						15,600				620			
56	6-25							1.99	1.26		500			
57	6-26				6.5						540			
58	6-27				6.6	1,200				0	580	69	30	1
59	6-28										580			
60	6-29										630			
61	6-30										590			
62	7-1							1.84	1.15		610			
63	7-2						16,500				660	67.4	32.6	0

Unit 4
450-500 mg/ℓ Magnifloc
15-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
64	7-3				7.0	2,350				26	520			
65	7-4							1.91	1.15		550			
66	7-5						17,000				580			
67	7-6										630			
68	7-7										670			
69	7-8							1.92	1.18		600			
70	7-9						16,100				620	70	30	
71	7-10				7.1	2,500				27	560			
72	7-11							1.84	1.10		600			
73	7-12						16,400				580			
74	7-13										620			
75	7-14										600			
76	7-15							1.83	1.09		650			
77	7-16										670			
78	7-17				6.9	2,400				0	630			
79	7-18							1.87	1.11		520			
80	7-19						15,400				590			
81	7-20										630			
82	7-21										620			
83	7-22							1.82	1.08		640			
84	7-23						13,400				560			
85	7-24				6.9	2,450					610	69	31	0
86	7-25							1.95	1.20		570			
87	7-26						20,300				580			
88	7-27										640			
89	7-28	36,200	2.98	2.27	6.9	2,500	18,300	2.12	1.33	26	670			

Unit 5
Control
30-Day Detention Time

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	4-25	37,900	3.44	2.64							795			
	4-26				6.9	3,000				14	760			
	4-27										-			
	4-28				6.8		34,400				610			
	4-29							5.08	2.85		605			
	4-30				6.8						590			
1	5-1										520			
2	5-2										500			
3	5-3				6.9	3,100				14	490			
4	5-4	34,900									455			
5	5-5		3.35	2.55			38,700				480			
6	5-6				6.8			4.29	2.40		445			
7	5-7				6.8						435			
8	5-8				6.8						465			
9	5-9				6.8	2,900				14	445			
10	5-10										470			
11	5-11										475			
12	5-12				6.8		42,000				420			
13	5-13				6.8						420			
14	5-14							3.62	2.04		410			
15	5-15										425			
16	5-16										405			
17	5-17				6.8	4,100				15	425			

Unit 5
Control
30-Day Detention Time
(Continued)

	INFLUENT				EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	5-18						30,100				330			
19	5-19										375			
20	5-20				6.8			3.25	1.81		385			
21	5-21										400			
22	5-22										435	75	25	
23	5-23										415			
24	5-24				6.9	2,900				27	405			
25	5-25										410			
26	5-26						33,000				425			
27	5-27				6.9			2.75	1.50		390			
28	5-28										400			
29	5-29										405			
30	5-30										370			
31	5-31				6.9	2,900				0	415	74	26	
32	6-1										375			
33	6-2	36,300	3.28	2.51			29,300				400			
34	6-3				7.0			2.64	1.20		380			
35	6-4										380			
36	6-5										375	73	27	
37	6-6										375			
38	6-7										370			
39	6-8						18,800				380			
40	6-9				7.0	2,700				28	360			

Unit 5
Control
30-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	6-10							2.42	1.31		360			
42	6-11				7.0						435			
43	6-12										420	71.5	28.5	
44	6-13		3.23	2.44							420			
45	6-14										270			
46	6-15				7.0	2,800				28	460			
47	6-16										430			
48	6-17						16,900				390			
49	6-18				7.1						400			
50	6-19	38,650						2.11	1.10		270			
51	6-20										410	71	29	
52	6-21				7.2	2,700					460			
53	6-22									0	360			
54	6-23										290			
55	6-24						14,000				490			
56	6-25							2.30	1.41		490			
57	6-26				7.0						350			
58	6-27				7.1	2,800				0	450	69	30	1
59	6-28										400			
60	6-29										440			
61	6-30										390			
62	7-1							1.69	0.87		450			
63	7-2						14,700				370	71	27.7	1.3

Unit 5
Control
30-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
64	7-3				7.1	2,900				80	370			
65	7-4							1.81	.93		420			
66	7-5						15,000				400			
67	7-6										410			
68	7-7										420			
69	7-8							-	-		380			
70	7-9						14,200				420	69	29	2
71	7-10				7.1	2,800				82	360			
72	7-11							1.60	.84		420			
73	7-12						14,800				390			
74	7-13										420			
75	7-14										380			
76	7-15							1.63	.83		420			
77	7-16						13,600				370			
78	7-17				7.0	2,700				0	460			
79	7-18							1.65	.85		340			
80	7-19						13,300				450			
81	7-20										390			
82	7-21										390			
83	7-22							1.55	.81		420			
84	7-23						12,800				370			
85	7-24				7.1	2,800					450	69	30.5	.5
86	7-25							1.60	.85		340			
87	7-26						12,200				440			
88	7-27										390			
89	7-28	40,400	3.14	2.36	7.1	2,800	16,500	1.78	.96	0	420			

Unit 6
325 mg/ℓ Alum
30-Day Detention Time

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
	4-25	37,900	3.44	2.64							715			
	4-26				6.9	2,700				14	740			
	4-27										-			
	4-28				6.8		40,000				635			
	4-29							5.20	2.90		585			
	4-30				6.8						595			
1	5-1										485			
2	5-2										415			
3	5-3				6.9	2,700				14	415			
4	5-4	37,000									415			
5	5-5		3.44	2.64			35,400				445			
6	5-6				6.8			4.40	2.49		405			
7	5-7				6.8						375			
8	5-8				6.8						400			
9	5-9				6.8	2,500				14	390			
10	5-10										380			
11	5-11										380			
12	5-12				6.7		34,000				370			
13	5-13				6.8						380			
14	5-14							3.72	2.16		355			
15	5-15										380			
16	5-16										320			
17	5-17				6.7	2,200				14	360			

Unit 6
325 mg/ℓ Alum
30-Day Detention Time
(Continued)

INFLUENT					EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
18	5-18						31,900				300			
19	5-19										305			
20	5-20				6.7			3.44	2.00		350			
21	5-21										365			
22	5-22										355	77.5	22.5	
23	5-23										360			
24	5-24				6.8	2,200				26	370			
25	5-25										340			
26	5-26						37,500				360			
27	5-27				6.7			3.04	1.76		350			
28	5-28										340			
29	5-29										340			
30	5-30										325			
31	5-31				6.8	2,700				55	345	76.5	23.5	
32	6-1										335			
33	6-2	36,800	3.31	2.54			30,100				370			
34	6-3				6.8			2.64	1.56		330			
35	6-4										305			
36	6-5										290	76	24	
37	6-6										340			
38	6-7										355			
39	6-8						22,700				370			
40	6-9				6.8	2,300				0	320			

Unit 6
325 mg/ℓ Alum
30-Day Detention Time
(Continued)

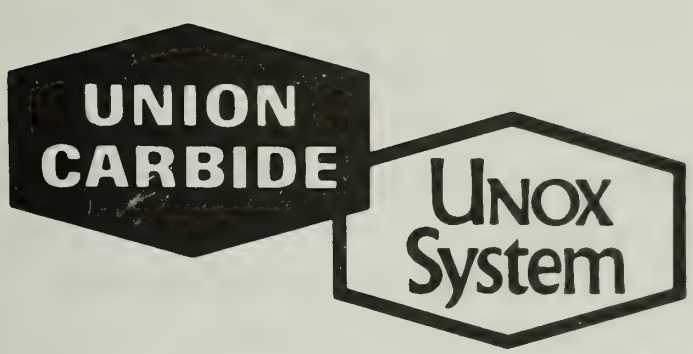
		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/l	TS %	VS %	pH	Alk mg/l	tot COD mg/l	TS %	VS %	Vol. Acids mg/l	Prod ml/d	CH_4 %	CO_2 %	N_2 %
41	6-10							2.67	1.57		320			
42	6-11				6.8						320			
43	6-12										315	75.5	24.5	
44	6-13		3.30	2.53							375			
45	6-14										200			
46	6-15				6.8	2,100				27	290			
47	6-16										340			
48	6-17						19,800				360			
49	6-18				6.8						360			
50	6-19	38,650						2.57	1.50		230			
51	6-20										380	71	29	
52	6-21				6.9	1,900					370			
53	6-22									0	330			
54	6-23										230			
55	6-24						17,300				370			
56	6-25							2.38	1.39		350			
57	6-26				6.8						330			
58	6-27				6.9	1,700				0	340	70	27	3
59	6-28										320			
60	6-29										350			
61	6-30										340			
62	7-1							2.25	1.30		350			
63	7-2						18,800				330	70.3	27.5	2.2

Unit 6
325 mg/ℓ Alum
30-Day Detention Time
(Continued)

		INFLUENT			EFFLUENT						GAS			
Day	Date	tot COD mg/1	TS %	VS %	pH	Alk mg/1	tot COD mg/1	TS %	VS %	Vol. Acids mg/1	Prod ml/d	CH_4 %	CO_2 %	N_2 %
64	7-3				6.8	2,000				0	290			
65	7-4							2.35	1.40		340			
66	7-5						18,900				340			
67	7-6										350			
68	7-7										350			
69	7-8							2.15	1.24		310			
70	7-9						18,500				340	71	28	1
71	7-10				6.8	1,900				0	310			
72	7-11							2.14	1.25		340			
73	7-12						18,800				320			
74	7-13										340			
75	7-14										340			
76	7-15										320			
77	7-16						18,500				320			
78	7-17				6.8	1,800				0	330			
79	7-18							2.08	1.19		310			
80	7-19						17,700				350			
81	7-20										340			
82	7-21										320			
83	7-22							2.10	1.23		330			
84	7-23						18,100				320			
85	7-24				6.9	1,800					340	69	27	4
86	7-25							2.14	1.28		310			
87	7-26						18,100				340			
88	7-27										340			
89	7-28	39,000	3.26	2.48	7.0	1,800	18,000	2.17	1.37	0	340			

APPENDIX I

APPENDIX I



WASTEWATER TREATMENT

Pilot Plant Report

THE CH2M/HILL STUDY OF SAN FRANCISCO SOUTHEAST AND NORTHPOINT TREATMENT PLANTS

UNION CARBIDE CORPORATION
LINDE DIVISION

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I SUMMARY AND CONCLUSIONS

A two-phase evaluation of the UNOX System has been completed with the Southeast and North Point wastewaters in San Francisco, California. This study included an investigation of the use of the Union Carbide Corporation high purity oxygenation system in treating a pilot scale primary effluent. The operating conditions and removals for the UNOX System are listed on Table I.

The daily average influent BOD_5 ranged from 44-442 mg/l and the COD ranged from 90-1233 mg/l, while the influent COD/BOD_5 ratio varying from 1.1 - 11.8. The influent pH during Phase I ranged from 5.5 to 10.5, with an average of 6.8, while during Phase II, the pH ranged from 5.8 to 8.2, with an average of 6.8. These ranges were also accompanied by drastic fluctuations in the other influent characteristics.

During the pilot plant program, the UNOX System was operated through a daily average organic loading range of 33-336 Lb. BOD_5/day/1000 $ft.^3$ and through a daily average food to micro-organism range of 0.12 - 1.44 Lb. BOD_5/day/Lb. MLVSS, with the loadings on an hourly basis being even greater. Even with these operating ranges and influent fluctuations, the system BOD_5 removal efficiency was 92% for the entire program and the COD removal efficiency was 66% for the entire program. The suspended solids removal efficiency was 80% and 76%, during Phases I and II respectively.

During Phase I the UNOX System was operated diurnally on Southeast wastewater at a retention time of 2.0 hours and a F/M of 0.48 Lbs. BOD_5/day/Lb. MLVSS. The system consumption was 0.69 Lb. oxygen/Lb. COD removed and the sludge production was 0.266 Lbs. VSS produced/Lb. COD removed.

During Phase II the system was operated diurnally on 24% Southeast and 73% North Point wastewaters, in addition to 3% digester supernatent. The retention time was 2.0 hours and the F/M was 0.29 Lb. BOD_5/day/Lb. MLVSS. If this phase is subdivided into two sections where one section represents an influent COD/BOD_5 of 5.7 to 6.6 and the other represents a COD/BOD_5 of 2.5 to 3.2, the oxygen consumption was 0.83 and 0.73 Lbs. O_2 utilized/Lb. COD removed, respectively. The overall sludge production was 0.237 Lbs. VSS produced/Lb. COD removed.

TABLE 1

"UNOX" SYSTEM
SAN FRANCISCO, CAL.

SYSTEM PERFORMANCE SUMMARY

AVERAGES

PARAMETERS				
PHASE	1		2	
DURATION, WEEKS	4		4	
OXYGENATION TIME				
Q, HRS.	2.0		2.0	
Q+R, HRS.	1.52		1.52	
RECYCLE FRACTION (R/Q), %	32		30	
BIOMASS LOADING				
LB. BOD5/DAY/LB.MLVSS	0.48		0.29	
LB. COD/DAY/LB.MLVSS	1.69		1.16	
ORGANIC LOADING				
LB. BOD5/DAY/1000 FT3	109		83	
LB. COD/DAY/1000 FT3	400		328	
MIXED LIQUOR SUSPENDED SOLIDS, MG/L	5535		5673	
MIXED LIQUOR VOLATILE SS, MG/L	4392		4529	
RECYCLE SS, MG/L	20196		27216	
CLARIFIER OVERFLOW RATE, GAL/DAY/FT2	581		586	
CLARIFIER MASS LOADING, LB.SS/DAY/FT2	32.0		33.7	
INFLUENT CONCENTRATIONS				
BIOCHEMICAL OXYGEN DEMAND				
TOTAL, MG/L	144		110	
SOLUBLE, MG/L				
CHEMICAL OXYGEN DEMAND				
TOTAL, MG/L	528		431	
SOLUBLE, MG/L	235		168	
SUSPENDED SOLIDS				
TOTAL, MG/L	186		122	
VOLATILE, MG/L				
EFFLUENT CONCENTRATIONS				
BIOCHEMICAL OXYGEN DEMAND				
TOTAL, MG/L	12		7	
SOLUBLE, MG/L				
CHEMICAL OXYGEN DEMAND				
TOTAL, MG/L	142		128	
SOLUBLE, MG/L	105		100	
SUSPENDED SOLIDS				
TOTAL, MG/L	33		24	
VOLATILE, MG/L	27		20	
REMOVALS				
BIOCHEMICAL OXYGEN DEMAND				
TOTAL, %	91		92	
SOLUBLE, %				
CHEMICAL OXYGEN DEMAND				
TOTAL, %	66		66	
SOLUBLE, %	76		71	
SUSPENDED SOLIDS				
TOTAL, %	80		76	
VOLATILE, %				
INFLUENT COD/BOD_5	3.67	6.15		2.85
OXYGEN CONSUMPTION				
LB.OXYGEN/LB.BOD5 REMOVED	2.14	3.61		1.18
LB.OXYGEN/LB.COD REMOVED	0.69	0.83		0.30
OXYGEN UTILIZATION, %	87		91	
SLUDGE PRODUCTION				
LB.TSS WASTED/LB.BOD5 REMOVED(A)	.238		.203	
LB.VSS WASTED/LB.BOD5 REMOVED(A)	.188		.160	
LB.TSS WASTED/LB.BOD5 REMOVED(B)	.337		.284	
LB.VSS WASTED/LB.BOD5 REMOVED(B)	.266		.237	
SLUDGE AGE (LB.MLVSS/LB.VSS WASTED), DAYS (B)	3.5		5.6	
SLUDGE VOLUME INDEX	38		34	
INITIAL SETTLING VELOCITY				
STIRRED (60RPH), FT/HR	8.3		8.1	
UNSTIRRED, FT/HR	8.1		8.1	

(A) CORRECTED FOR INVENTORY SHIFT
(B) CORRECTED FOR INVENTORY SHIFT AND EFFLUENT

II INTRODUCTION

A two-phase evaluation of the UNOX System at the Southeast Wastewater Treatment Plant in San Francisco, California has been completed. The pilot study was undertaken jointly by the City of San Francisco, CH_2M Hill, and the Linde Division of Union Carbide Corporation in order to obtain performance parameters, design criteria, and to demonstrate the applicability of the UNOX System in the proposed treatment plant expansion. This expansion, to include secondary treatment, will be made necessary by government restrictions on the quality of wastewater that can be discharged to the San Francisco Bay.

The existing waste treatment facilities consist of grit chambers, flocculation tanks and rectangular primary clarifiers. The influent to the plant is chlorinated in the sewer lines, then the effluent from the primaries is chlorinated in contact tanks before it's discharged to the Bay. The primary sludge is anaerobically digested, vacuum filtered, and burned or used for land fill.

One of the main objectives of the study was to confirm design data, while treating Southeast primary effluent. The other was to confirm design data, while treating primary effluent comprised of Southeast, North Point, and digester supernatant, which will comprise the proposed treatment plant.

The following sections include a description of the pilot plant facilities and the monitoring equipment, the phase of operation, and a tabular presentation of all the data collected.

III PILOT PLANT FACILITIES AND PROCESS MONITORING

Pilot Plant Facilities

The UNOX System "Mobile" Pilot Plant trailer and external clarifier, in conjunction with a surge tank for pumping mixed liquor to the clarifier, was employed in this study. The gas tight biological reactor consists of four cocurrent gas-liquid stages. Each of the stages is a completely mixed unit, and since these stages are operating in series, the overall system approximates a plug flow reactor. The waste and the return activated sludge enter the first stage separately. Each stage contains a sparge/impeller contacting unit, which consists of 1) a sparger which is a hollow hub with rotating spokes equipped with orifices, and 2) a marine type propeller which is used as the primary liquid pumping device.

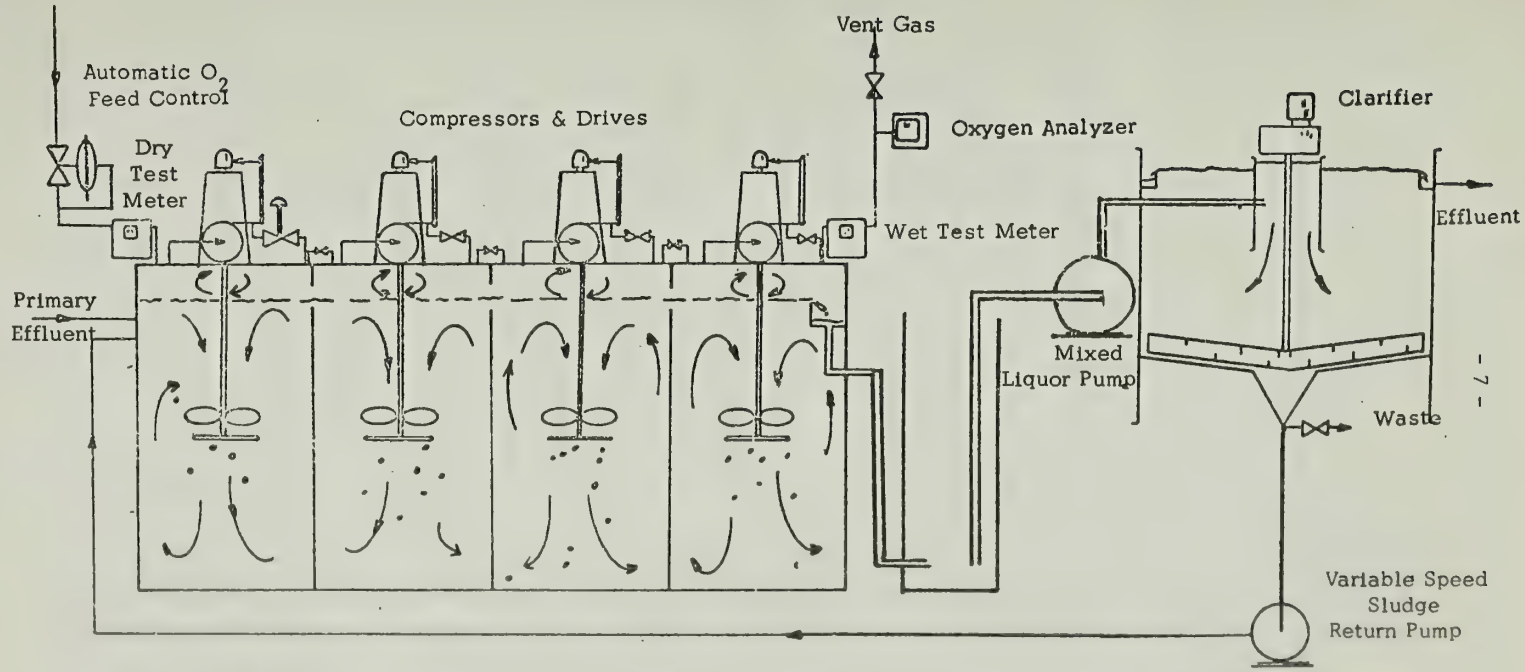
Oxygen gas was fed into the first stage gas space which was maintained at a pressure of about 1.5 inches of water. Gas flow and the reduction of gas back mixing were promoted by a slight pressure drop between successive stages. As the oxygen enriched gas passed through the system, small diaphragm compressors above each of the stages pumped the gas down the hollow mixer shafts and through the rotating spargers. The oxygen was automatically fed to the first stage in such a manner that the rate was controlled by the first stage gas pressure. The unit acts like a respirometer, as uptake increases the pressure tends to drop and the feed oxygen increases. The gas flowed through the gas space openings between stages and the waste gas finally was vented to the atmosphere. The oxygen feed rate and the last stage vent gas rate were measured continuously.

The mixed-liquor from the reactors flowed to a surge tank, then pumped to a center-feed clarifier, which contained a peripheral effluent weir. The clarifier also contained a plow type scraper with center take-off for settled solids, which were withdrawn with a variable speed Moyno pump for recycle. A separate Moyno pump was used in conjunction with an automatic timer for semi-continuous sludge wasting.

The plant influent was pumped by a variable speed Moyno pump so that a range of feed rates and therefore a comparable range of liquid retention times could be simulated. The mixers equipped on each stage also had variable speed drives to control power densities. The gaseous hydrocarbon level was monitored through the use of a combustible gas analyzer.

FIGURE 1

"UNOX" System
San Francisco Treatment Plant



BIOLOGICAL REACTOR
Liquid Depth - 5'2"
Sludge Volume = 400 gal.
Total Liquid Volume = 1600 gal.

Surge Tank

SECONDARY CLARIFIER

Diameter, ft.	7
Liquid Depth, ft	9
Volume, gal.	2560

Process Monitoring

The process monitoring for the UNOX System took two forms: analytical and operational. The analytical sampling was performed by continuous samplers and manual four hour grabs, both were composited for 24 hours. The settling tests, both stirred and unstirred, were conducted each day using a grab sample of mixed liquor from the last stage.

The analytical analysis for physical properties, chlorinated hydrocarbons, bioassay, radioactive components, nutrients, and metals, in addition to the usual analysis for organic components and solids were conducted according to Standard Methods. The analysis were performed by the CH_2M Hill mobile lab and two other independent laboratories. A fraction of all samples were frozen and stored for future reference.

The operational monitoring took the form of meters and probes to indicate the effective use of the oxygen gas. These monitoring methods included liquid flow meters, dissolved oxygen probes, pH meters, oxygen flow meters, and oxygen gas analyzers.

A summary of the above mentioned analysis and sampling schedules is presented in Tables 2, 3, and 4.

Table 2

"UNOX" System

San Francisco, California

Analytical	Method of Sampling
1. BOD	Composite
A. Secondary Influent and Effluent	Continuous sampler
2. COD	
A. Secondary Influent and Effluent	Continuous sampler
B. Total and Soluble	
3. Total Solids Mixed-Liquor	Composite 250 ml/4 hr. at constant rate
4. Return Solids	Composite 260 ml/4 hr. at constant rate
Operational	
5. D.O. Levels	Measured daily with Weston and Stack Instrument. Weston and Stack calibrated by Winkler Titration; probes and meters adjusted as required.
6. pH Meter	Portable Kernco pH meter.
7. Oxygen Percent	Servomex analyzer calibrated in the field in 100% oxygen gas and air.
8. Liquid Flow	Feed and return pump calibrated by volume/time every day.
9. Gas Flow	Measured be wet gas meter.
10. Temperature	Thermometers installed in gas and liquid phases.

TABLE 3

"UNOX" System
San Francisco, California

PHASE I SAMPLING SCHEDULE

METALS		CHEMICAL		PHYSICAL	
Al	25	Acdy	0	Float	25
Sb	5	Alk	25	Setlb.	25
As	10	BOD-5	25	T. Susp.	25
Ba	10	BOD-U	0	Turb.	25
Be	5	Br	5	Color	25
Bi	0	CO_2	0	Cond.	0
B	10	Cl	5	Odor	0
Cd	25	COD	25	T.D.S.	5
Ca	5	D.O.	25	T.S.	5
Cr	25	Fl	10	T.V.S.	10
Co	5	I	5	V.S.S.	25
Cu	25	Oil-G	25	Temp.	25
CN	25	pH	25	**BIOASSAYS**	
Fe	25	Phenol	25		
Pb	25	SO_4	5	TLM-24	10
Mg	10	SO_3	10	TLM-48	10
Mn	25	$S^=$	0	TLM-96	10
Hg	10	Surf.	10	%-24	10
Mo	10	Hard	5	%-48	10
Ni	25	TOC	10	%-96	10
P	0	SOL COD	25	Tox U.	10
K	0			**CHLORO-HYDRO**	
Se	10				
Si	0			Lindane	5
Ag	25	**NUTRIENTS**		Hept-E	5
Na	5			DDE	5
Sr	0	NH_3-N	25	DDD	5
Tl	5	NO_3	5	DDT	5
Sn	5	NO_2	5	Dieldrin	5
Ti	5	Org-N	5	T.C.H.C.	25
V	5	N	10	Aldrin	5
Zn	25	Ortho-PO_4	10	Chlord.	5
Zr	0	Tot-PO_4	25	Endrin	5
Au	0			Heptaclr	5
U	0			Methclr	5
Li	0			Toxapn	5
W	0			Org.-P	5
Cr-6	10	**RADIOACTIVE**		Carb	5
Fe-2	10			2-4-D	5
		Alpha	25	P.C.B.	25
		Beta	5		
		Ra 226	0		
		Sr 90	0		

The number denotes the quantity of analysis where all of the samples were 24-hour composites.

TABLE 4

"UNOX" System
San Francisco, California

PHASE II SAMPLING SCHEDULE

METALS		CHEMICAL		PHYSICAL	
Al	14	Acdy	0	Float	25
Sb	5	Alk	25	Setlb.	25
As	13	BOD-5	25	T. Susp.	25
Ba	5	BOD-U	0	Turb.	25
Be	5	Br	5	Color	25
Bi	0	CO_2	0	Cond.	5
B	8	Cl	5	Odor	0
Cd	13	COD	25	T.D.S.	5
Ca*	5	D.O.	25	T.S.	5
Cr	13	Fl	8	T.V.S.	5
Co	5	I	5	V.S.S.	25
Cu	13	Oil-G	25	Temp.	25
CN*	13	pH	25	**BIOASSAYS**	
Fe	13	Phenol	13		
Pb	13	SO_4	5	TLM-24	13
Mg*	13	SO_3	13	TLM-48	13
Mn	13	$S^=$	0	TLM-96	13
Hg	13	Surf.	8	%-24	13
Mo	8	Hard	5	%-48	13
Ni	13	TOC	13	%-96	13
P	0	SOL BOD	16	Tox U.	13
K*	0	SOL COD	25	**CHLORO-HYDRO**	
Se	8				
Si	0			Lindane	5
Ag	13	**NUTRIENTS**		Hept-E	5
Na*	5			DDE	5
Sr	5	NH_3-N	25	DDD	5
Tl	5	NO_3	5	DDT	5
Sn	5	NO_2	5	Dieldrin	5
Ti	5	Org-N	5	T.C.H.C.	13
V	5	N	13	Aldrin	5
Zn	13	Ortho-PO_4	13	Chlord.	5
Zr	0	Tot-PO_4	25	Endrin	5
Au	0			Heptaclr	5
U	0			Methclr	5
Li	5			Toxapn	5
W	0	**RADIOACTIVE**		Org.-P	5
Cr-6	13			Carb	5
Fe-2	13	Alpha	13	2-4-D	5
		Beta	3	P.C.B.	13
		Ra 226	0		
		Sr 90	0		

The number denotes the quantity of analysis where all of the samples were 24-hour composites.

Hydrocarbon Monitoring System

The gas spaces above Stages 1 and 4 were continuously monitored by a combustible gas analyzer, which was calibrated with a 1 percent mixture of propane in air. The warning alarm was adjusted to sound at 25 percent of the lower explosive limit (LEL) for hexane, while the danger alarm was set to sound at 50 percent of the LEL for hexane. Neither alarm sounded during the entire program, indicating that a hydrocarbon problem does not exist with these wastewaters.

IV OPERATION AND PERFORMANCE

Operating Phases - General

The UNOX System was diurnally fed primary effluent from a pilot scale primary system for the two phases of operation with the main objective of producing the best possible effluent. A brief description of these two phases is presented in Table 4.

Phase I of the program was devoted to treating Southeast primary effluent. The operating conditions achieved were a retention time of 2.0 hours, a MLVSS of 4392 mg/l, an influent BOD_5 of 144 mg/l, and a F/M of 0.48 Lb. BOD/day/Lb. MLVSS.

Phase II of the program was spent treating the combined North Point and Southeast wastewaters with small digester supernatant component. The operating conditions for this phase were a retention time of 2.0 hours, a MLVSS of 4529 mg/l, an influent BOD_5 of only 110 mg/l, and a F/M of 0.29 Lb. BOD/day/Lb. MLVSS.

TABLE 5

UNOX System
San Francisco, California

Operating Phases

PHASE	DATE	MODE	WASTE	OPERATING CONDITIONS
1	9/3/73 - 9/27/73	Diurnal	Southeast; Primary Effluent	2.0 hrs. RT_Q; R/Q of 32%; MLVSS = 4392 mg/l
2	10/2/73 - 10/26/73	Diurnal	73% North Point, 24% Southeast, 3% digester supernatant; Primary Effluent	2.0 hrs. RT_Q; R/Q of 30%; MLVSS = 4529 mg/l

Phase I

In this first phase of operation the UNOX System was fed Southeast wastewater from a pilot scale primary system. A quantitative description of the daily average influent wastewater characteristics is shown in Table 5. The daily chemical oxygen demand (COD) of the influent varied by 1143 mg/l (minimum to maximum), with an average of 528 mg/l, where as the daily five day biochemical oxygen demand (BOD_5) varied by 368 mg/l, with an average of 144 mg/l. The soluble fraction of the COD was 44 percent. The influent suspended solids averaged 186 mg/l and varied by 259 mg/l, with the volatile content averaging 56 percent. The raw influent pH varied from 1.2 to 10.7, however the primary effluent only varied from 5.5 to 10.5, with an average of 6.8. The influent characteristics varied sharply with the most drastic changes being on Friday.

A daily compilation of the operating conditions for Phase I is presented in Table 6, and the results for this phase are presented in Table 7. The BOD_5 and COD removals averaged 91 and 66 percent, respectively, with effluent concentrations of 12 and 105 mg/l, respectively. Suspended solids removal was 80 percent with an average effluent suspended solids of 33 mg/l.

At an average MLSS concentration of 5535 mg/l, the initial settling velocity (stirred) was 8.3 ft/hr, and the sludge volume index averaged 38, demonstrating the good solid-liquid separation and compaction characteristics of the mixed liquor in the UNOX System.

TABLE 6

"UNOX" SYSTEM
SAN FRANCISCO, CALIFORNIA
DAILY AVERAGE CHARACTERISTICS OF WASTEWATER FEED
PHASE 1

	INFLUENT BOD MG/L	INFLUENT COD MG/L	SOLID INFLUENT COD MG/L	SUSPENDED SOLIDS MG/L	VOLATILE SUSPENDED SOLIDS MG/L	pH	AMMONIA NITROGEN MG/L	PHOSPHOROUS MG/L
AVERAGE	144	528	235	186	104	6.80	13.4	4.6
MAXIMUM	442	1,233	676	348	140	7.39	22.6	11.0
MINIMUM	74	90	90	73	47	6.13	2.3	1.3
NUMBER MEASUREMENT	25	25	25	24	4	25	25	25

TABLE 7

"UNOX" SYSTEM
SAN FRANCISCO, CAL.

OPERATING CONDITIONS
PHASE 1

DATE	OXYGENATION TIME HRS(Q)	R/Q %	MIXED LIQUOR TEMP F	MIXED LIQUOR TSS MG/L	MIXED LIQUOR % VOL	INITIAL SETTLING VELOCITY FT/HR	CLARIFIER O FLOW RATE GAL/FT2 /DAY	CLARIFIER MASS LOADING LB TSS/ FT2/DAY	RECYCLE SOLIDS %	SLUDGE VOLUME INDEX	BIOMASS LOADING LB BOD/ LB MLVSS /DAY	BIOMASS LOADING LB COD/ LB MLVSS /DAY	ORGANIC LOADING LB BOD/ 1000FT3 /DAY	ORGANIC LOADING LB COD/ 1000FT3 /DAY
9 3 1973	2.22	60	71	3640	80	4.2	520	22.4	1.25	69	0.27	0.97	50	177
9 4 1973	1.98	30	71	3680	74	11.1	586	21.3	1.19	38	1.17	5.51	200	937
9 5 1973	1.98	30	72	3870	81	11.1	586	22.4	1.19	39	0.54	1.52	106	299
9 6 1973	1.98	30	73	4830	80	10.1	586	27.9	1.58	33	0.27	1.32	65	320
9 7 1973	1.98	30	73	7460	77	9.7	586	43.1	1.56	24	0.18	1.15	63	413
9 8 1973	1.98	30	75	7580	83	9.4	586	43.8	1.68	-	0.25	1.16	100	458
9 9 1973	1.98	27	73	7060	86	9.4	586	39.7	1.75	-	0.19	0.57	74	216
9 10 1973	1.96	26	73	5700	77	11.1	586	31.9	1.81	-	0.32	1.12	88	309
9 11 1973	1.98	26	73	5740	-	8.5	586	32.1	1.86	36			93	484
9 12 1973	1.98	27	72	7260	83	10.6	586	41.2	2.37	23	0.47	1.11	179	418
9 13 1973	1.96	30	72	5220	84	8.4	586	30.3	1.96	42	0.58	1.06	159	288
9 14 1973	1.98	30	72	4640	88	9.0	586	26.9	2.20	41	0.24	1.60	61	407
9 15 1973	1.98	30	71	5260	81		586	30.5	2.21	-	0.36	1.08	97	288
9 16 1973	1.98	30	70	-	-	7.2	586		2.15	-			60	68
9 17 1973	1.98	30	71	-	-	8.3	586		2.30	-			65	315
9 18 1973	1.98	30	72	-	-	10.7	586		1.99	-			75	626
9 19 1973	1.98	30	73	5020	74	10.4	586	29.1	2.31	32	1.44	2.70	336	629
9 20 1973	1.98	30	71	3620	76	7.3	586	21.0	2.67	-1	0.72	2.79	125	481
9 21 1973	1.98	30	72	6280	78	6.3	586	36.4	2.36	37	0.25	1.45	76	442
9 22 1973	1.98	30	72	5680	70	8.0	586	32.9	2.23	35	0.56	1.23	140	307
9 23 1973	1.98	30	72	5400	77	5.1	586	31.3	1.91	44	0.32	1.36	84	353
9 24 1973	1.98	30	72	4320	73	7.0	586	25.0	2.73	49	0.60	2.46	119	487
9 25 1973	1.98	30	72	-	-	7.7	586		2.42				69	259
9 26 1973	1.98	30	73	6640	81	8.7	586	38.5	2.43	29	0.32	1.67	108	563
9 27 1973	1.98	30	74	5280	75	6.3	586	30.6	2.39	42	0.59	1.89	146	465
AVERAGE	1.99	32	72	5535	79	8.3	581	32.0	2.02	38	0.48	1.69	109	400

* DOES NOT INCLUDE SOLIDS INVENTORY SHIFT

TABLE 8
"UNOX" SYSTEM
SAN FRANCISCO, CALIFORNIA

ORGANIC AND SUSPENDED SOLIDS REMOVALS
PHASE 1

DATE	CHEMICAL OXYGEN DEMAND TOTAL INFL MG/L	TOTAL EFFL MG/L	SOLUBLE INFL MG/L	SOLUBLE EFFL MG/L	TOT REM %	BIOCHEMICAL OXYGEN DEMAND TOTAL INFL MG/L	TOTAL EFFL MG/L	SOLUBLE INFL MG/L	SOLUBLE EFFL MG/L	TOT REM %	SUSPENDED SOLIDS TOTAL INFL MG/L	TOTAL EFFL MG/L	TOTAL REM %	VOLATILE INFL MG/L	VOLATILE EFFL MG/L	VOLATILE REM %
9 3 1973	262	202	228	98	23	74	10	-	-	86	73	18	75	-	1	-
9 4 1973	1233	159	676	155	87	263	45	-	-	83	107	46	57	-	21	-
9 5 1973	394	121	192	138	69	140	8	-	-	94	167	44	74	-	43	-
9 6 1973	421	136	236	201	68	85	8	-	-	91	174	24	86	-	24	-
9 7 1973	544	106	212	56	81	83	9	-	-	89	179	33	82	-	28	-
9 8 1973	603	141	318	79	77	132	9	-	-	93	204	27	87	-	26	-
9 9 1973	284	108	121	82	62	97	7	-	-	93	125	23	82	-	3	-
9 10 1973	406	42	640	81	90	116	12	-	-	89	234	23	90	-	22	-
9 11 1973	637	135	190	121	79	123	20	-	-	84	234	19	92	-	17	-
9 12 1973	550	133	190	93	76	235	21	-	-	91	78	29	63	-	27	-
9 13 1973	379	154	171	78	59	209	10	-	-	95	135	27	80	-	27	-
9 14 1973	536	230	160	121	57	80	8	-	-	90	238	47	80	-	47	-
9 15 1973	379	31	214	52	92	127	13	-	-	90	240	61	75	-	52	-
9 16 1973	90	138	214	97	53	79	7	-	-	91	129	49	62	-	36	-
9 17 1973	415	45	177	60	89	86	5	-	-	94	126	35	72	-	33	-
9 18 1973	824	102	150	118	88	99	5	-	-	95	348	35	90	-	19	-
9 19 1973	827	106	246	128	87	442	13	-	-	97	247	29	88	135	19	86
9 20 1973	633	103	218	39	84	164	11	-	-	93	332	32	90	140	30	79
9 21 1973	582	57	219	75	90	100	7	-	-	93	160	22	86	-	18	-
9 22 1973	404	122	235	81	70	184	9	-	-	95	316	57	82	-	9	-
9 23 1973	465	191	268	89	59	110	12	-	-	89	166	22	87	-	20	-
9 24 1973	641	36	212	86	94	157	7	-	-	96	197	31	84	-	29	-
9 25 1973	341	321	90	113	6	91	15	-	-	84	126	16	87	94	8	91
9 26 1973	741	349	144	246	53	142	11	-	-	92	-	36	-	47	36	23
9 27 1973	612	276	165	147	55	192	14	-	-	93	140	45	68	-	39	-
AVERAGE	528	142	235	105	66	144	12	-	-	91	186	33	80	104	27	70

* DOES NOT INCLUDE SOLIDS INVENTORY SHIFT

Phase II

The UNOX System feed was primary effluent comprised of 24% Southeast and 73% North Point wastewaters, and 3% digester supernatant. The daily average influent wastewater characteristics are listed in Table 8. The COD varied by 972 mg/l with an average of 431 mg/l while the soluble portion was 39%. The BOD_5 varied by 217 mg/l with an average of 110 mg/l and the total suspended solids averaged 122 mg/l.

The daily operating conditions for this phase are listed in Table 9, and the removals are shown in Table 10. The total BOD_5 removal was 92% and the total COD removal was again 66%. The suspended solids removal was 76% while the effluent turbidity was only 10 FTU.

At an average MLSS concentration of 5673 mg/l, the initial settling velocity (stirred) averaged 8.3 ft/hr and the sludge volume index averaged 34. Once again, these numbers substantiate the good solid-liquid separation and compaction characteristics of the mixed liquor.

TABLE 9
"UNOX" SYSTEM
SAN FRANCISCO, CAL.

CHARACTERISTICS OF WASTEWATER FEED
PHASE 2

	INFLUENT BOD MG/L	INFLUENT COD MG/L	SOL INFL COD MG/L	SUSPENDED SOLIDS MG/L	VOL SUSP SOLIDS MG/L	PH	AMMONIA NITROGEN MG/L	PHOSPHOROUS MG/L
AVERAGE	110	431	168	122	133	6.75	12.4	2.4
MAXIMUM	261	1115	373	314	176	6.97	17.2	4.0
MINIMUM	44	143	22	62	56	6.22	7.6	1.2
NO.MEAS	25	25	13	25	4	25	25	25

TABLE 10

"UNOX" SYSTEM
SAN FRANCISCO, CAL.

OPERATING CONDITIONS
PHASE 2

DATE	OXYGENATION TIME HRS(Q)	R/Q %	MIXED LIQUOR TEMP F	MIXED LIQUOR TSS MG/L	MIXED LIQUOR % VOL	INITIAL SETTLING VELOCITY FT/HR	CLARIFIER O FLOW RATE GAL/FT2 /DAY	CLARIFIER MASS LOADING LB TSS/ FT2/DAY	RECYCLE SOLIDS %	SLUDGE VOLUME INDEX	BIOMASS LOADING LB BOD/ LB MLVSS /DAY	BIOMASS LOADING LB COD/ LB MLVSS /DAY	ORGANIC LOADING LB BOD/ 1000FT3 /DAY	ORGANIC LOADING LB COD/ 1000FT3 /DAY
10 2 1973	1.98	30	72	5220	81	7.7	586	30.3	2.48	40	0.66	2.05	174	543
10 3 1973	1.98	30	73	5561	78	7.0	586	32.2	2.62	38	0.22	1.86	61	503
10 4 1973	1.98	30	73	5641	81	7.7	586	32.7	2.54	35	0.18	1.42	52	407
10 5 1973	1.98	30	73	5489	80	9.1	586	31.8	2.96	39	0.26	0.76	71	210
10 6 1973	1.98	30	71	5631	80	9.1	586	32.6	2.60	34	0.36	2.30	103	648
10 7 1973	1.98	30	67	5580	80	7.0	586	32.4	2.53	38	0.13	0.86	35	239
10 8 1973	1.98	30	68	5494	80	6.6	586	31.8	2.61	40	0.18	1.43	49	394
10 9 1973	1.98	30	70	5464	81	7.0	586	31.7	2.71	38	0.12	1.42	33	395
10 10 1973	1.98	30	71	5834	82	9.1	586	33.8	2.57	24	0.66	2.84	198	847
10 11 1973	1.98	30	72	5421	80	10.5	586	31.4	2.49	30	0.20	1.28	55	350
10 12 1973	1.98	30	72	5497	79	9.8	586	31.9	2.58	31	0.28	0.80	77	219
10 13 1973	1.98	30	73	5286	79	5.6	586	30.6	2.64	53	0.20	1.17	51	304
10 14 1973	1.98	30	73	5298	81	8.2	586	33.2	2.97	32	0.31	0.41	83	109
10 15 1973	1.98	30	71	5798	81	8.4	586	36.3	2.60	29	0.34	0.74	100	217
10 16 1973	1.98	30	72	5921	80	9.0	586	37.1	2.80	27	0.24	0.73	70	217
10 17 1973	1.98	30	73	6237	80	8.1	586	39.1	2.90	29	0.34	0.81	105	252
10 18 1973	1.98	30	72	5333	80	7.6	586	33.4	2.77	36	0.37	1.25	100	334
10 19 1973	1.98	30	72	5652	79	7.6	586	36.7	2.68	34	0.36	0.98	100	274
10 20 1973	1.98	30	73	5796	80	8.3	586	36.3	2.70	35	0.32	0.88	94	257
10 21 1973	1.98	30	73	5720	79	11.0	586	33.2	3.05	33	0.31	0.73	87	207
10 22 1973	1.98	30	70	5641	80	10.4	586	32.7	2.92	28	0.24	0.84	68	236
10 23 1973	1.98	30	69	5881	78	10.0	586	34.1	2.69	26	0.18	0.70	51	199
10 24 1973	1.98	30	71	6241	79	7.9	586	36.2	2.86	30	0.26	0.99	81	306
10 25 1973	1.98	30	71	5795	80	7.2	586	33.6	2.82	33	0.33	0.82	96	236
10 26 1973	1.98	30	72	6403	78	11.1	586	37.1	2.94	27	0.28	0.94	89	296
AVERAGE	1.98	30	71	5673	80	8.3	586	33.7	2.72	34	0.29	1.16	83	328

* DOES NOT INCLUDE SOLIDS INVENTORY SHIFT

TABLE 11
"UNOX" SYSTEM
SAN FRANCISCO, CAL.

ORGANIC AND SUSPENDED SOLIDS REMOVALS
PHASE 2

DATE	CHEMICAL OXYGEN DEMAND TOTAL INFL MG/L	TOTAL EFFL MG/L	SOLUBLE INFL MG/L	SOLUBLE EFFL MG/L	TOT REM %	BIOCHEMICAL OXYGEN DEMAND TOTAL INFL MG/L	TOTAL EFFL MG/L	SOLUBLE INFL MG/L	SOLUBLE EFFL MG/L	TOT REM %	SUSPENDED SOLIDS TOTAL INFL MG/L	TOTAL EFFL MG/L	TOTAL REM %	VOLATILE INFL MG/L	VOLATILE EFFL MG/L	VOLATILE REM %
10 2 1973	714	221	177	71	69	229	12	-		95	192	13	93			
10 3 1973	662	117	-	-	82	80	10	-		87	114	20	82			15
10 4 1973	535	172	-	-	68	69	3	-		95	62	14	78			4
10 5 1973	276	153	145	18	45	93	16	-		83	222	13	94			13
10 6 1973	853	115	-	127	87	135	11	-		92	180	26	86			24
10 7 1973	314	82	171	61	74	46	11	-		76	96	33	66			32
10 8 1973	518	126	-	39	76	64	8	-		87	178	30	83			16
10 9 1973	520	134	-	171	74	44	9	-		80	62	52	16			44
10 10 1973	1115	225	373	198	80	261	7	-		97	314	18	94			16
10 11 1973	460	26	165	70	94	73	4	-		94	76	40	47			22
10 12 1973	288	153	-	168	47	101	4	-		96	124	17	87			8
10 13 1973	400	33	156	58	92	67	5	-		92	76	25	68			22
10 14 1973	143	87	-	66	39	109	4	-		96	80	24	70			18
10 15 1973	285	85	195	86	70	132	8	-		94	90	21	77			13
10 16 1973	286	105	-	-	63	92	5	-		95	140	28	80			28
10 17 1973	332	108	-	88	67	138	5	-		96	110	14	87			14
10 18 1973	439	50	175	99	89	131	6	-		95	122	14	89			14
10 19 1973	360	109	-	92	70	131	8	-		94	114	24	79			19
10 20 1973	338	390	115	343	15	124	6	-		95	82	25	70			24
10 21 1973	273	122	22	29	55	115	5	-		95	176	22	88			22
10 22 1973	311	72	-	36	77	89	8	-		91	102	35	66			35
10 23 1973	262	53	135	56	80	67	7	-		90	76	14	82			13
10 24 1973	403	164	191	95	59	106	10	-		90	96	12	88			12
10 25 1973	310	121	-	93	61	126	8	-		94	90	27	70			27
10 26 1973	389	165	164	143	58	117	6	-		95	72	35	51			29
AVERAGE	431	128	168	100	66	110	7	-		92	122	24	76			20

* DOES NOT INCLUDE SOLIDS INVENTORY SHIFT

V RESULTS & DISCUSSION

Organic Removals

Figure 2 presents BOD_5 removal as a function of the organic loading, which is defined as pounds BOD_5 applied per day per 1000 cubic feet of reactor volume. The slope of the line represents the fraction or the percent BOD_5 removal capability of the system, over the organic loading range of study. This correlation reveals that the UNOX System BOD_5 removal efficiency averaged 92 percent over the range of loadings studied for both phases, 33-336 Lbs. BOD_5/100 cf/day. This resulted in an effluent total BOD_5 that averaged only 12 mg/l for Phase I and 7 mg/l for Phase II. Figure 3 shows a similar relationship for COD removal, where the removal efficiency, as indicated, was 66% over a range of 68-937 Lbs. COD/1000 cf/day. It should be noted that both Figures 2 and 3 indicate that at higher loading ranges, the removal efficiencies increase, indicating that the UNOX System would operate even more efficiently at higher loadings.

The food to micro-organism ratios investigated ranged from 0.12 to 1.44 Lb. BOD_5/Lb. MLVSS/day, as is indicated in Figure 4. Again, the UNOX System averaged 92% removal rate. Figure 5 shows a similar relationship for COD removals. As indicated, the average COD removal efficiency was 66% over a range of 0.41 to 5.51 Lbs./COD/Lb. MLVSS/day. These figures also indicate that at higher loadings the system removal efficiency is greater.

FIGURE - 2

"UNOX" SYSTEM

SAN FRANCISCO, CALIFORNIA

BOD_5 Removed as a function of organic loading

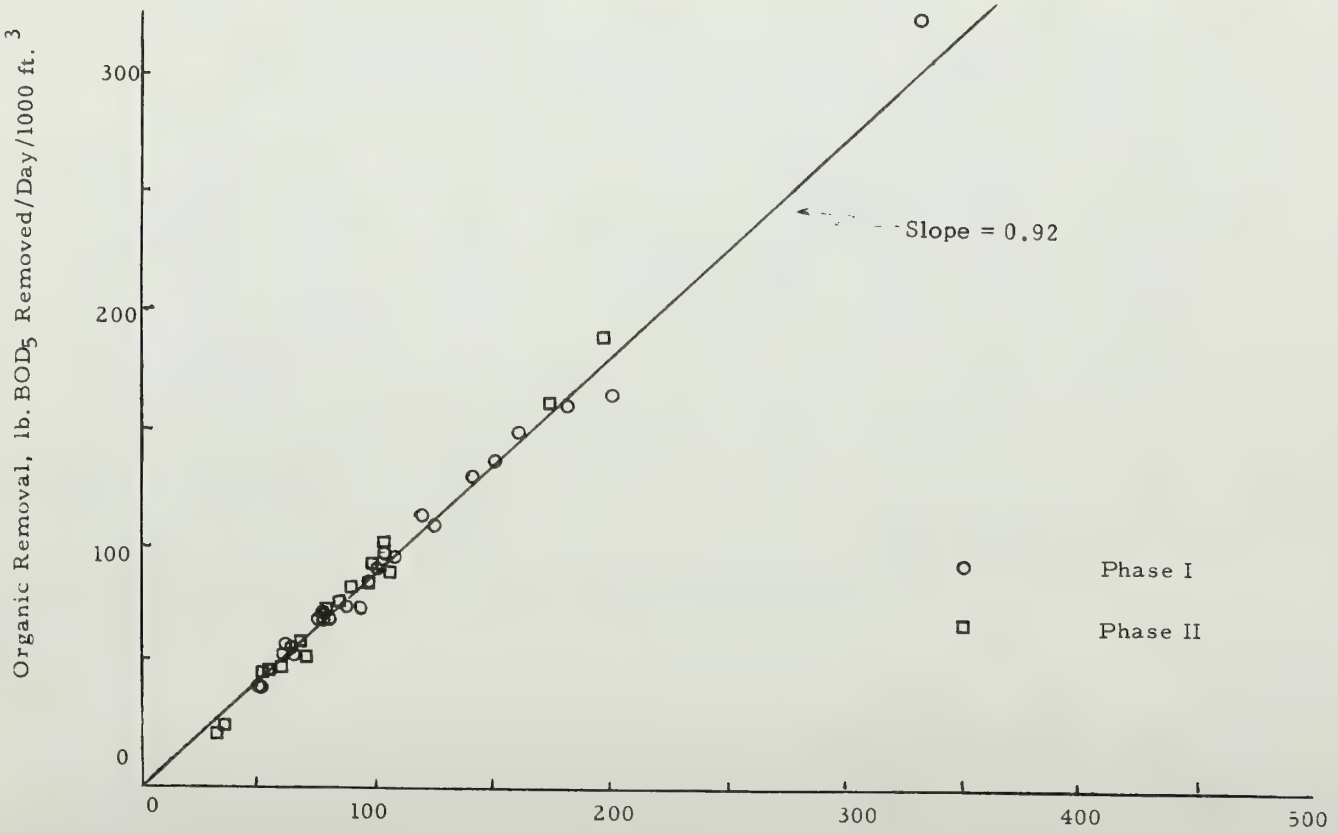


FIGURE 3

"UNOX" SYSTEM

SAN FRANCISCO, CALIFORNIA

COD removed as a function of organic loading

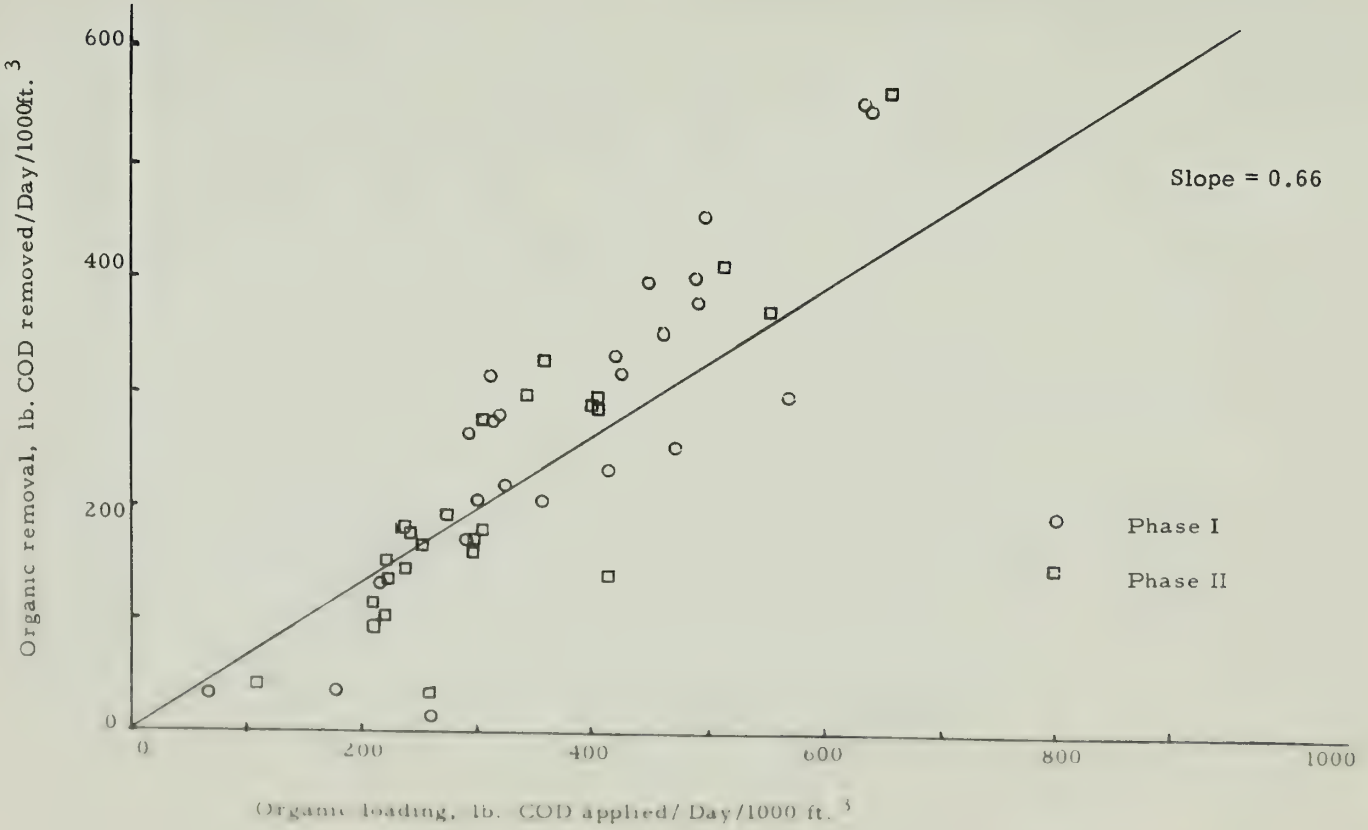


FIGURE - 4

"UNOX" SYSTEM

SAN FRANCISCO, CALIFORNIA
BOD_5 REMOVED AS A FUNCTION OF APPLIED F/M

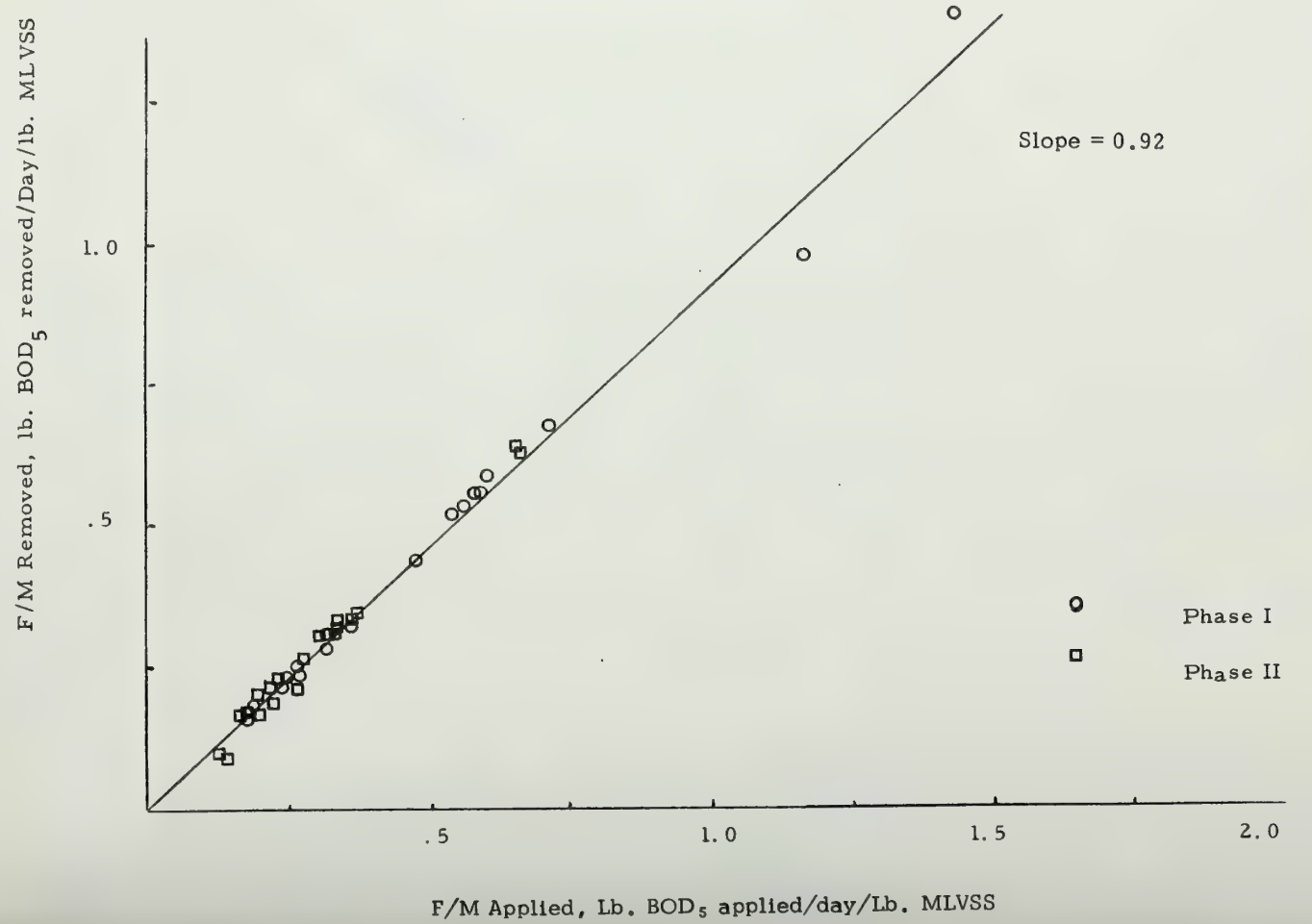
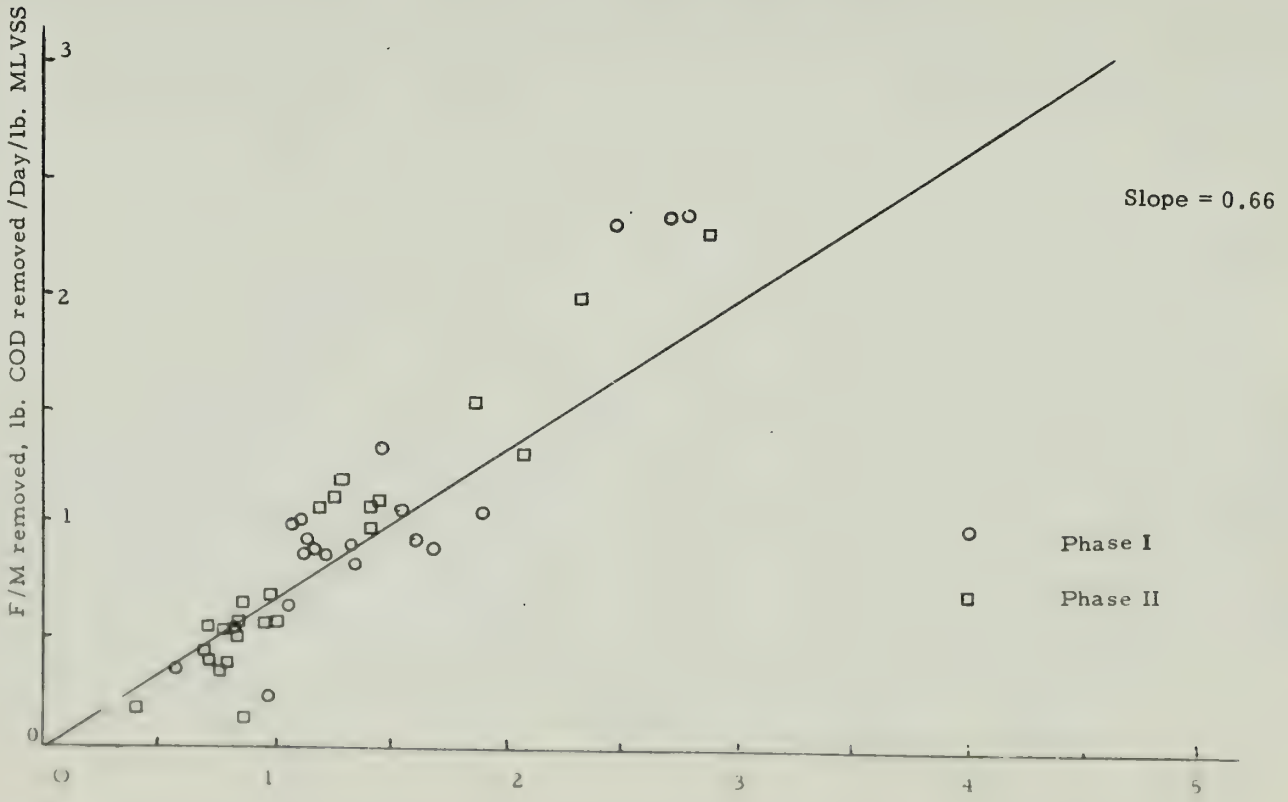


Figure - 5

"Unox" System

San Francisco, California

COD removed as a function of applied F/M



Oxygen Consumption

The total oxygen requirements in the activated sludge system are related to the oxygen required for synthesis and that associated with endogenous respiration. Since the UNOX System is a closed system and the oxygen containing gas is monitored for both flow and concentration, the oxygen consumed per unit of BOD_5 and COD removed can be readily determined. At high food to micro-organism ratios, the oxygen requirement per unit BOD_5 removed is governed mainly by that required for cell synthesis, since the degree of endogenous respiration is relatively low as indicated by higher excess sludge production at high F/M ratios. At low food to micro-organism ratios the relative degree of auto-oxidation increases, the unit oxygen requirement increases, and the unit quantity of excess sludge produced decreases.

An equally important factor in determining the oxygen requirement is the COD/BOD_5 ratio. Increasing the COD/BOD_5 ratio, results in increasing the oxygen consumption per unit BOD_5 removed, which is opposite to the effect of increasing F/M.

An oxygen leak in the system during much of the program prevented calculating oxygen consumption ratios for BOD_5 and COD removed based on metered oxygen values. As a result, these ratios were calculated using the COD-oxygen equivalence relationship; they are shown in Table 18. Since COD is a measure of chemical oxygen equivalents, it follows that the oxygen used is directly related to the COD removed. In general, the following equation may be applied:

$$COD_{removed} - COD_{wasted} - COD_{accumulated} = O_2 \text{ utilized}$$

$COD_{removed}$ refers to the COD removed from the influent, COD_{wasted} refers to the COD in the waste sludge, and $COD_{accumulated}$ refers to the COD accumulated in the system, which is due to MLSS and clarifier solids content changes. If the system were at steady state, the $COD_{accumulated}$ term would be negligible, and the COD_{wasted} term would increase or decrease to make the equation balance. If the system is not at steady state, the non-zero $COD_{accumulated}$ term represents a portion of the oxygen consumed by the system. These oxygen utilizations agreed with ratios calculated by material balance, when there were no oxygen leaks.

Figure 6 represents a correlation of oxygen consumption (based on the COD balance) per unit COD removed as a function of the applied COD biomass loading. F/M based on COD was used in this case since the wide variation in influent COD/BOD_5 would have made a similar plot based on BOD_5 F/M useless, due to the scatter of data. The effect of the influent COD/BOD_5 on oxygen consumption per pound of BOD_5 and COD is illustrated by Figure 7, which is also based on the COD balances.

The calculated oxygen consumption during Phase I was 0.69 Lbs. O_2/ Lb. $COD_{removed}$ and 2.14 Lbs. O_2/Lb. $BOD_{removed}$. It should be noted that these consumptions are a function of the measured solids wasted and do not include the solids lost by surge tank malfunctions. If solids are wasted and they are not included in the wasting term, then the calculated consumption would be higher than the actual consumption. This seems to be the case

since these numbers are higher than consumptions observed during other UNOX studies on similar wastewater.

The Phase II consumptions should be more accurate, because of fewer surge tank malfunctions; however they were still experienced. During this phase, the influent COD/BOD_5 ratio changed from 5.7 - 6.6 to 2.5 - 3.2, during the third week of operation. Since the COD/BOD_5 significantly effects the oxygen consumption, this phase should be subdivided into two sections when evaluating the consumption ratios. During the first two weeks when the influent COD/BOD_5 ratio ranged from 5.7 to 6.6, the oxygen consumption averaged 3.61 Lbs. O_2/Lb. BOD_5 removed and 0.83 Lbs. O_2/Lb. COD removed. During the second two week period the influent COD/BOD_5 ratio ranged from 2.5 to 3.2, and the oxygen consumption averaged 1.39 Lbs. O_2/Lb. BOD_5 removed and .73 Lbs. O_2/Lb. COD removed.

TABLE 12

"UNOX" System
San Francisco, California

OXYGEN CONSUMPTION BY COD BALANCE

PHASE	DATE (WEEK OF)	BOD REMOVED LBS/DAY	COD REMOVED LBS/DAY	COD WASTED LBS/DAY	COD ACCUMULATED LBS/DAY	CALCULATED OXYGEN CONSUMPTION LBS/DAY	LBS. O_2 UTILIZED/ LBS. BOD REMOVED	LBS. O_2 UTILIZED/ LBS. COD REMOVED
1	9/02/73	18.6	70.0	2.26	14.55	53.2	2.86	.76
1	9/09/73	20.7	54.1	----	-----	----	----	---
1	9/16/73	25.4	71.8	2.95	13.30	55.6	2.19	.77
1	9/23/73	20.5	52.7	13.60	10.77	28.3	1.38	.54
AVERAGE		21.3	62.2	6.27	12.87	45.7	2.14	.69
2	9/30/73	18.0	73.2	0	13.2	60.0	3.33	.82
2	10/07/73	14.1	65.6	6.4	4.4	54.8	3.89	.84
AVERAGE		16.05	69.4	3.2	8.8	57.4	3.61	.83
2	10/14/73	19.0	29.0	14.2	- 4.5	19.3	1.02	.67
2	10/21/73	15.2	33.9	11.6	- 4.3	26.6	1.75	.78
AVERAGE		17.1	31.5	12.9	- 4.4	23.0	1.39	.73

FIGURE 6

"UNOX" System
San Francisco, California

OXYGEN CONSUMPTION AS A FUNCTION OF APPLIED COD BIOMASS LOADING

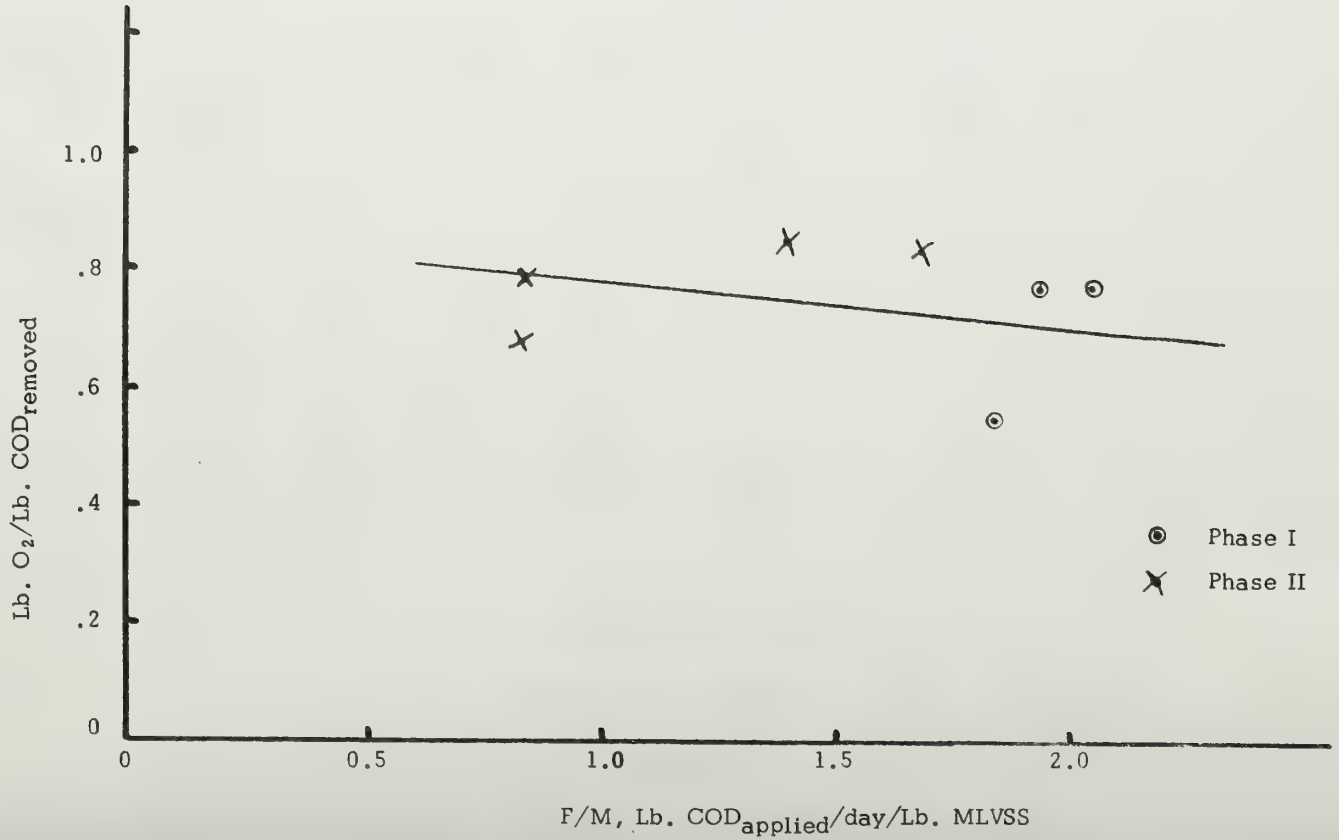
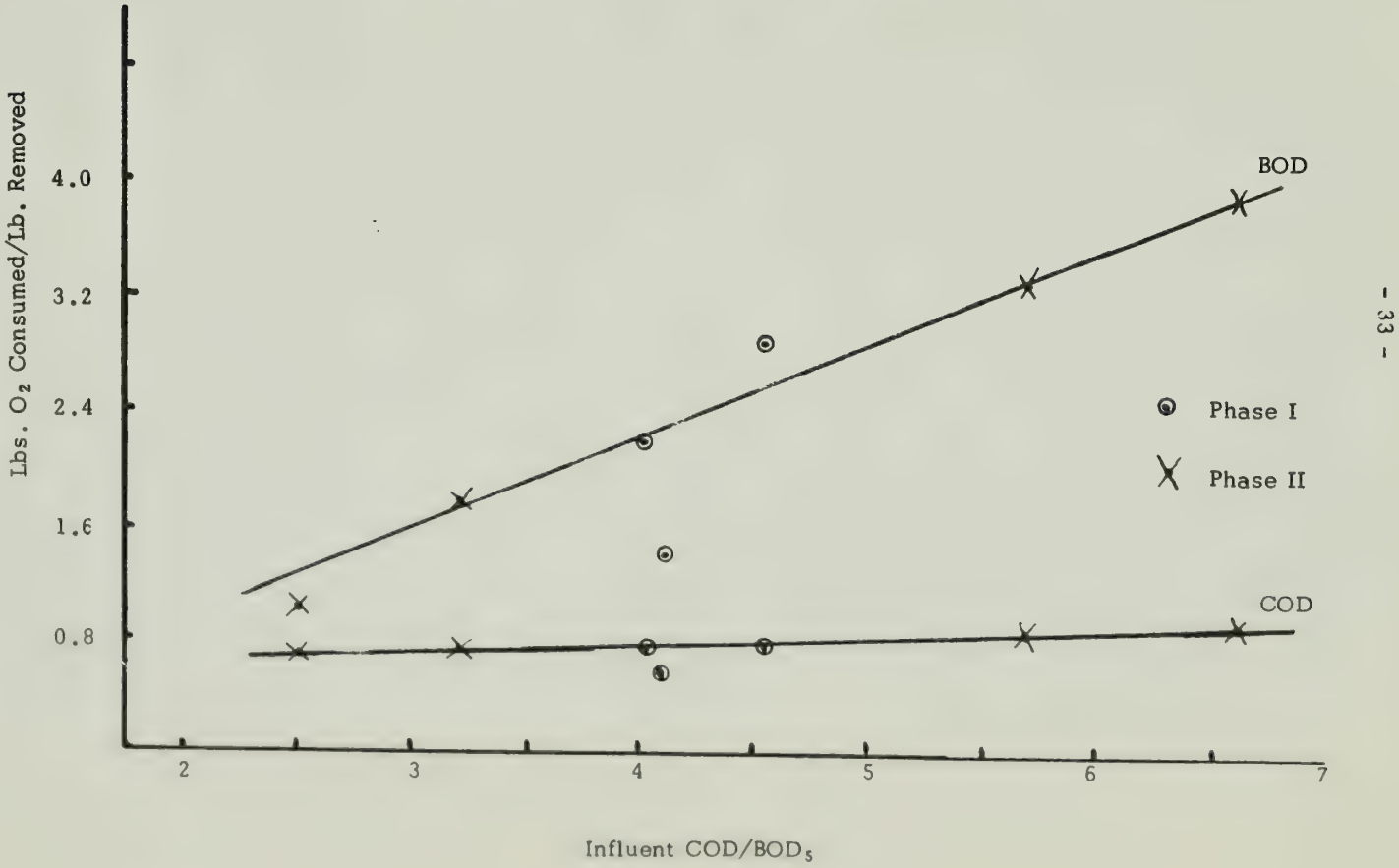


FIGURE 7

"UNOX" System
San Francisco, California

OXYGEN CONSUMPTION AS A FUNCTION OF INFLUENT COD/BOD_5



Excess Sludge Production

The extent of net or excess solids production is a function of the degree of endogenous respiration occurring in the oxygenation system. The degree of endogenous respiration is governed by the food to micro-organism ratio. Since the UNOX System employs a multistage gas-liquid contacting approach, the food to micro-organism ratio decreases from stage-to-stage. Therefore, stabilization is occurring in the latter stages resulting in decreased sludge production. It has also been determined that a high dissolved oxygen environment will result in a lower sludge yield due to the highly aerobic character of the biological floc. In essence, this means that all floc particles are in a working mode and when placed in a food limiting situation, will therefore undergo a higher degree of endogenous respiration or auto-oxidation than floc in a low D.O. environment. The measurement of sludge production in any biological process is difficult and requires careful control of wasting schedules and system sludge inventory levels, as well as careful analytical monitoring of the system. If care is not taken, misleading results can easily be obtained.

Solid production data taken during the San Francisco pilot plant program was corrected for solids inventory changes in the clarifier and summarized in Table 13. These sludge production results are illustrated in Figure 8 which shows the effect of COD biomass loading on sludge production. Again, like with the oxygen balances, the waste listed does not include the solids lost due to surge tank malfunctions.

In order to estimate the total solids production at any given COD biomass loading, the value obtained from Figure 8 for sludge production should be divided by 0.79 for Phase I and 0.80 for Phase II, which is the average VSS/TSS for those phases. For example, at a biomass loading of 1.5 lb. COD/day/lb. MLVSS, waste for disposal is about 0.16 lb. VSS/lb. COD_R which will then yield about 0.20 lb. TSS per lb. COD_R after dividing by 0.79.

TABLE 13

"UNOX" SYSTEM
SAN FRANCISCO, CAL.

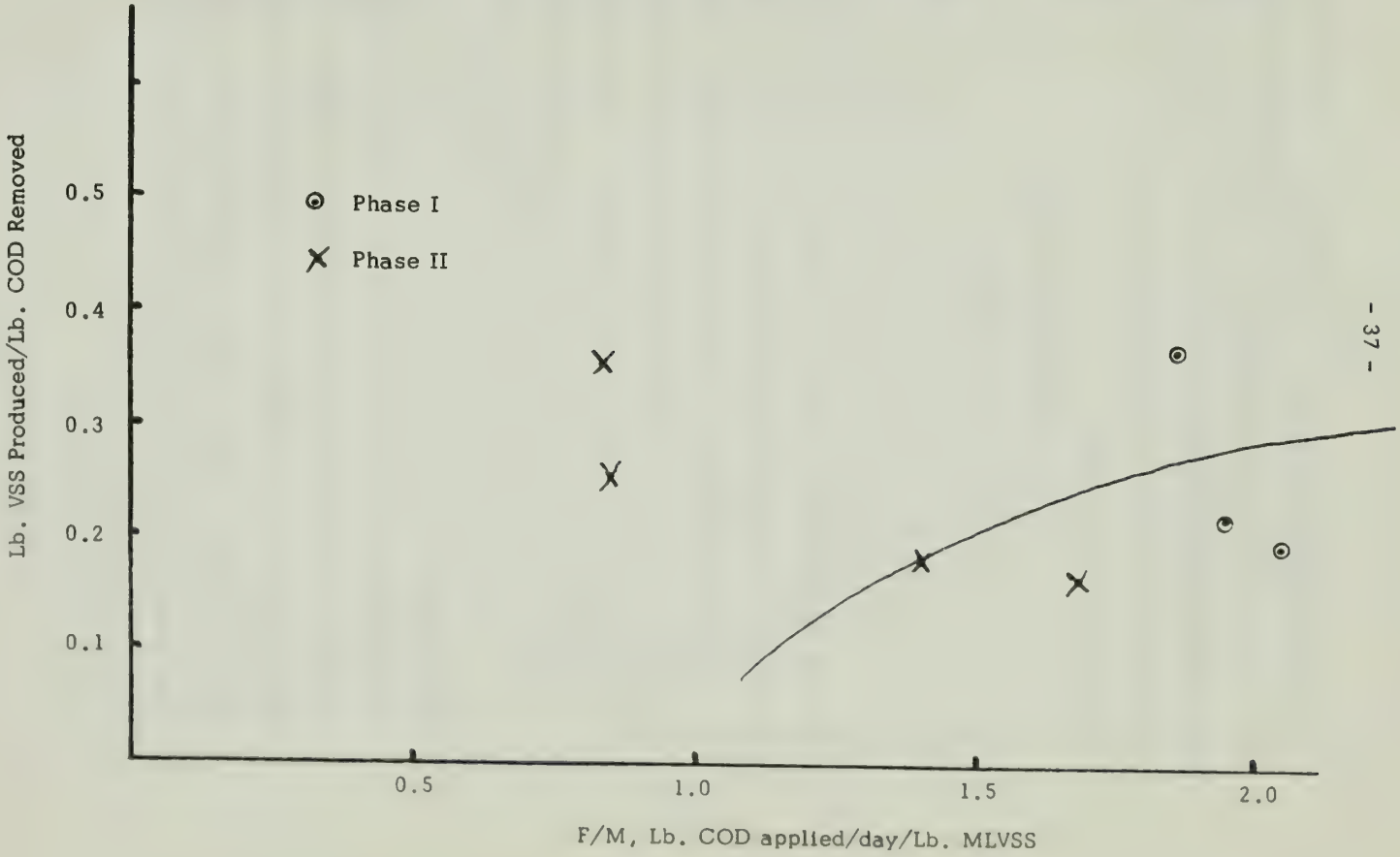
SUMMARY OF SOLIDS PRODUCTION DATA

PHASE	DATE (WEEK OF)	COD REMOVED LBS/DAY	EFFLUENT VSS LBS/DAY	VSS WASTED LBS/DAY	VSS ACCUMULATED LBS/DAY	VSS WASTE+ACCUM. LBS/DAY	VSS PRODUCED LBS/DAY	SLUDGE RETENTION TIME DAYS	LBS VSS WASTE+ACCUM./ LB. COD REMOVED	LBS VSS PRODUCED/ LB. COD REMOVED	F/M LBS COD APPLIED/ DAY/LB MLVSS
1	9 2 1973	70.0	4.93	1.37	8.82	10.20	15.13	3.64	.146	.216	1.94
1	9 9 1973	54.1	4.51	----	----	-----	-----	----	----	----	1.09
1	9 16 1973	71.8	3.80	1.79	8.06	9.85	13.65	3.74	.137	.190	2.04
1	9 23 1973	52.7	4.28	8.24	6.53	14.77	19.04	3.21	.280	.361	1.85
	AVERAGE	62.2	4.38	3.80	7.80	11.61	15.94	3.53	.188	.266	1.73
2	9 30 1973	73.2	2.08	0.00	9.85	9.85	11.93	4.92	.135	.163	1.68
2	10 7 1973	65.6	3.69	4.77	3.28	8.05	11.74	5.00	.123	.179	1.40
2	10 14 1973	29.0	3.01	10.59	-3.36	7.23	10.24	5.95	.249	.353	0.83
2	10 21 1973	33.9	3.73	8.65	-3.21	5.44	8.57	7.29	.160	.253	0.84
	AVERAGE	50.4	3.13	6.00	1.64	7.64	10.77	5.79	.167	.237	1.19

FIGURE 8

"UNOX" System
San Francisco, California

VOLATILE SUSPENDED SOLIDS PRODUCED AS A FUNCTION OF APPLIED COD BIOMASS LOADING



Solids-Liquid Separation

The wastewater settling characteristics can generally be described by a model developed by Union Carbide Corporation which is based on the Kynch-Dick solids-liquid separation theory. This model has the form of $V_i = A\ (C_i \times 10^{-6})^{-n}$, where,

V_i = initial settling velocity, ft/hr

C_i = total solids concentration, mg/l

A and n are characteristic constants for any particular waste.

By using the RSS, the MLSS, the clarifier overflow rate, the percent recycle observed during the pilot plant program, and by assuming "n" equal to 2.26, a solids-liquid separation model for San Francisco wastewater can be developed. The constant, n, has been shown by numerous, previous, studies equal to 2.26 for primary effluent and should hold true in this case. The model thus developed, $V_i = (7.2 \times 10^{-5})(C_i \times 10^{-6})^{-2.26}$, for Phase I and $V_i = (6.7 \times 10^{-5})(C_i \times 10^{-6})^{-2.26}$ for Phase II, is shown in Figure 9 and Figure 10.

The settling velocities predicted by the model are a fairly good approximation of most of the ISV's measured in the daily settling test. The inconsistency in Phase I mixed liquor suspended solids data should be indicative of the emphasis placed on the Phase I settling model. These daily ISV's were arrived at by settling a mixed liquor sample in a stirred one-liter graduate cylinder. The full scale clarifier should perform even better since there would be a relatively small sidewall-liquid interface area to volume

ratio, compared to the small clarifier employed in the pilot plant operation. The clarifier model applies to the thickening characteristics of the sludge, and should be a conservative equation for sludge thickening in the full scale system.

FIGURE 9

"UNOX" System
San Francisco, California

PHASE I

INITIAL SETTLING VELOCITY
AS A FUNCTION OF INITIAL SOLIDS CONCENTRATION

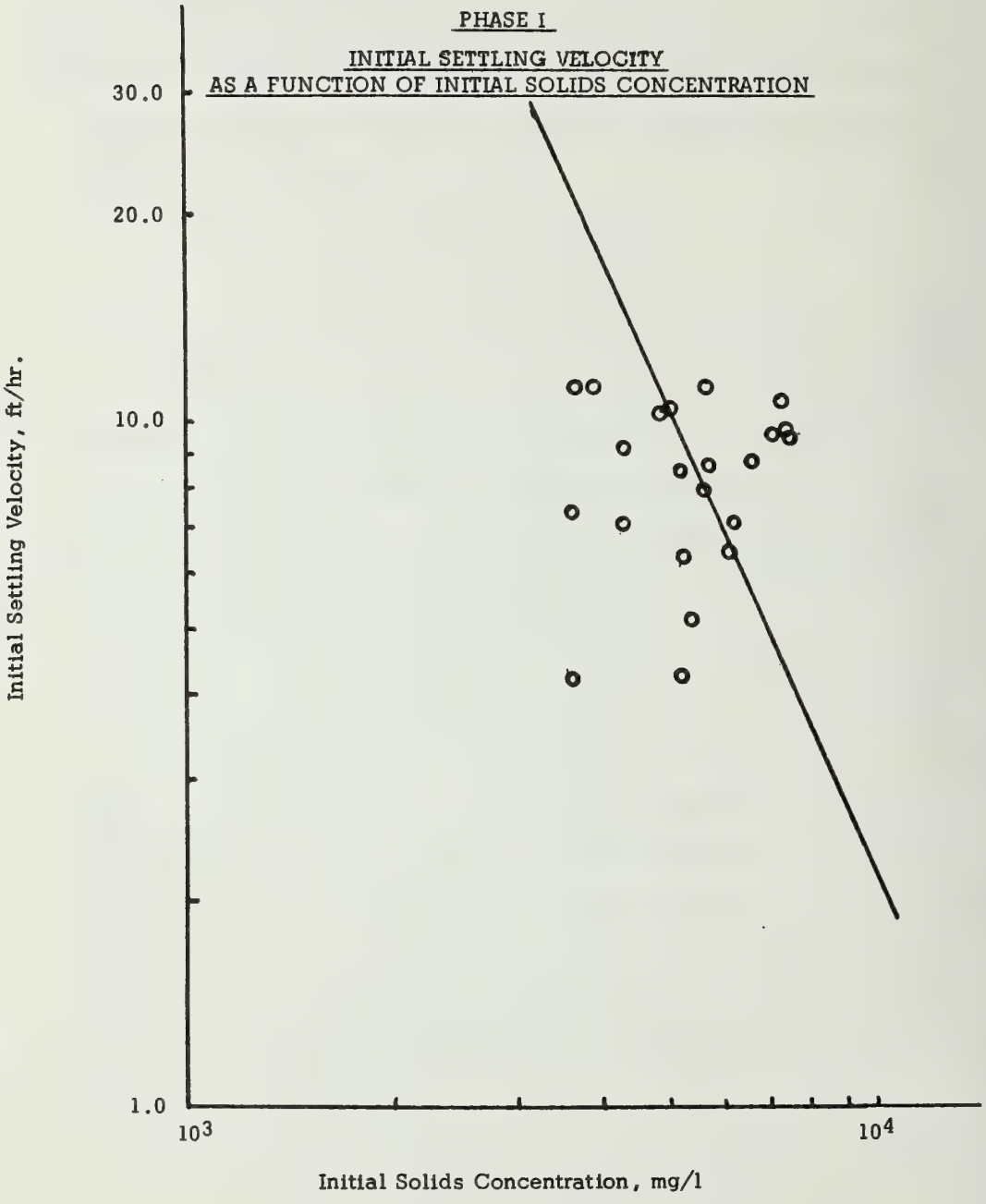
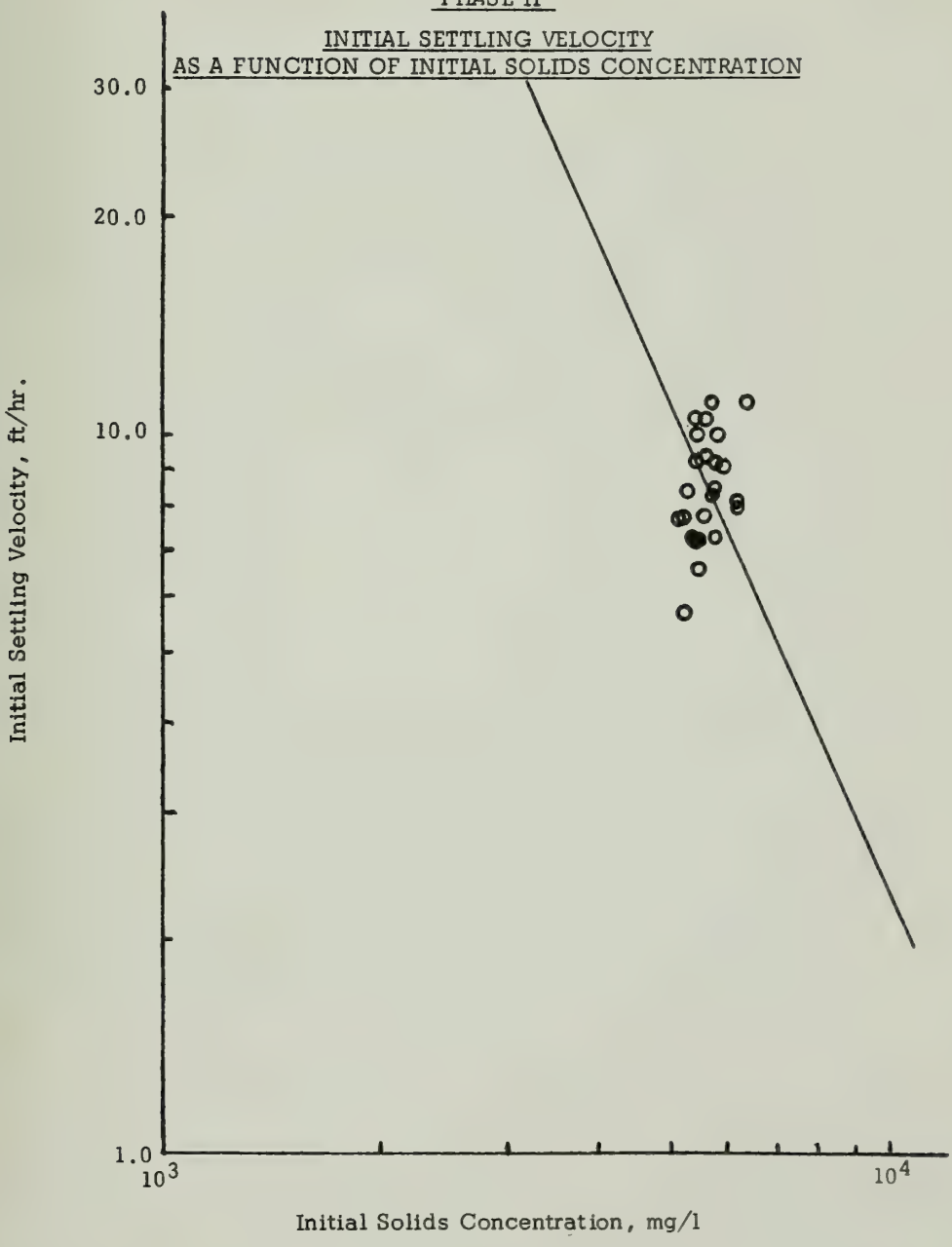


FIGURE 10

"UNOX" System
San Francisco, California

PHASE II

INITIAL SETTLING VELOCITY
AS A FUNCTION OF INITIAL SOLIDS CONCENTRATION



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